PB83-242529

Draft Environmental Impact Statement
North Carolina Barrier Island
Wastewater Management

(U.S.) Environmental Protection Agency
Atlanta, GA

Sep 82

U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-242529

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30365

EPA 904/9-83-108b
June 1983

Environmental Impact Statement

Draft

North Carolina Barrier Island Wastewater Management

Technical Reference Document
Environmental Inventory Report

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC INFORMATION

PB83-242529

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PERFORMER: Environmental Protection Agency, Atlanta, GA.
Region IV.
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This report is the second report of the Environmental Impact Statements (EIS) process. It describes existing data for the natural and manmade environments, indicates potential data limitations and addresses the issues of special concern to the EIS study. The focus of the EIS is to identify the sources of water quality degradation, investigate appropriate solutions to these problems, and evaluate the economic and environmental effects of implementing appropriate technologies.

KEYWORDS: *Barrier Islands, *Sewage treatment,
*Environmental impact statements-draft.

Available from the National Technical Information Service,
Springfield, Va. 22161

PRICE CODE: PC A18/MF A01

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV - ATLANTA

NORTH CAROLINA BARRIER ISLANDS
ENVIRONMENTAL IMPACT STATEMENT

TECHNICAL REFERENCE DOCUMENT
ENVIRONMENTAL INVENTORY REPORT

SEPTEMBER 1982

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GLOSSARY

ACOE	U.S. Army Corps of Engineers
AEC	Areas of Environmental Concern
BOD	Biological oxygen demand
CAMA	Coastal Area Management Act
CMP	Coastal Management Program
CPRC	Coastal Plains Regional Commission
CRC	Coastal Resources Commission
EDA	Economic Development Administration
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHA	Federal Housing Administration
FIA	Federal Insurance Administration
FmHA	Farmer's Home Administration
FOCZM	Federal Office of Coastal Zone Management
FWS	U.S. Fish and Wildlife Service
HUD	Department of Housing and Urban Development
NCDEM	North Carolina Division of Environmental Management
NCDHR	North Carolina Department of Human Resources
NCDNRCD	North Carolina Department of Natural Resources and Community Development
NCGS	North Carolina General Statute
NOAA	National Oceanic and Atmospheric Administration
NWR	National Wildlife Refuge
SA, SB, SC	Water quality classifications
SBA	Small Business Administration
SCS	U.S. Soil Conservation Service
TSS	Total suspended solids
USCGS	U.S. Coast Guard
USDA	U. S. Department of Agriculture
USDC	U. S. Department of Commerce
USEPA	U. S. Environmental Protection Agency
WWTP	Wastewater treatment plant

METRIC CONVERSION CHART

1 inch (in.) - 2.54 centimeter (cm)	1 cm = 0.394 in.
1 foot (ft) = 0.305 meter (m)	1 m = 3.28 ft
1 mile (mi) = 1.61 kilometer (km)	1 km = 0.621 mi
1 square foot (ft^2) = 0.0929 square meter (m^2)	1 m^2 = 10.76 ft^2
1 acre (ac) = 0.405 hectare (ha)	1 ha = 2.47 ac
1 gallon (gal) = 3.79 liter (l)	1 l = 0.264 gal
1 million gallons per day (mgd) = 3,790 m^3/d	1 m^3/d = 0.000264 mgd
degrees F = 1.6 C° + 32	degrees C = (F° - 32)(.625)
1 pound (lb) = 454 gram (g)	1 g = 0.00220 lb

Environmental impact Statements (EIS)

1.0 INTRODUCTION

ENVIRONMENTAL INVENTORY REPORT ESTABLISHES BASELINE CONDITIONS IN THE STUDY AREA

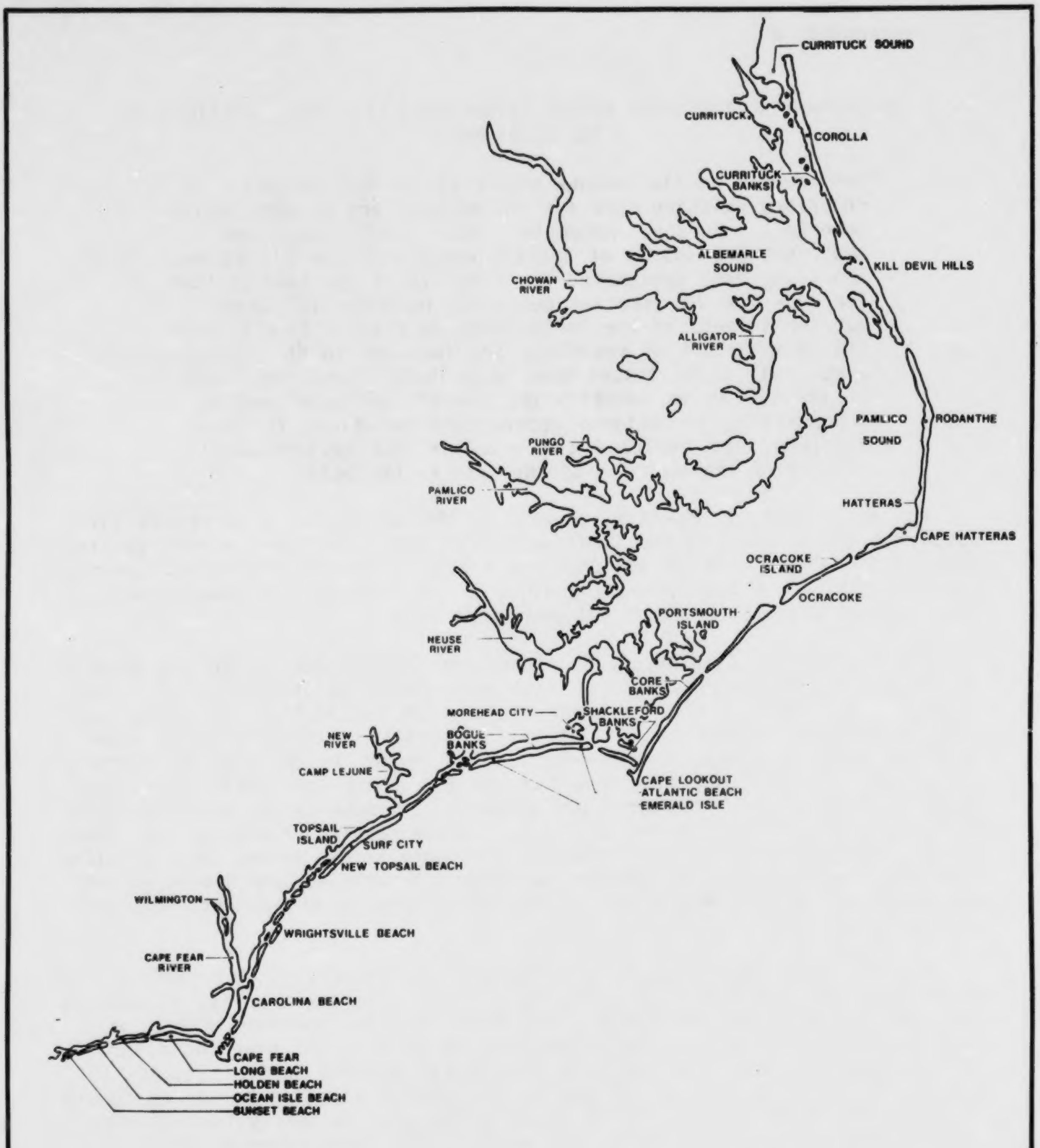
This report is the second report of the EIS process. It describes existing data for the natural and manmade environments, indicates potential data limitations and addresses the issues of special concern to the EIS study. The study area designated for this EIS is the same as that for the six 201 studies but also includes all other barrier islands of the North Carolina coast. In all, over 483 km (300 mi) of coastline are included in this study area. Six major issues have been identified. The focus of the EIS is to identify the sources of water quality degradation, investigate appropriate solutions to these problems, and evaluate the economic and environmental effects of implementing appropriate technologies.

The Environmental Inventory Report is the second of a series of six documents which leads to the Draft and Final EIS. The first report was the Plan of Study (POS), which outlined the tasks, schedule, and budget comprising the EIS. The four remaining reports are Alternatives Development, Alternatives Evaluation, Draft EIS and Final EIS.

The Environmental Inventory concludes the initial data gathering stage of an EIS. All secondary (existing) data are identified and collected. Data necessary for the EIS cover a broad spectrum of information including land use, population, community facilities, ecological characteristics, water quality, soils, geology, and hydrology. The report is designed to identify and define the existing data base for the EIS study area while indicating where data voids or limitations are present. In some cases, existing data are re-analyzed to assess the accuracy of study results or provide new information for the EIS. The Environmental Inventory Report serves as a baseline from which alternative wastewater management strategies are developed and evaluated and against which the environmental impacts of each strategy will be measured.

The EIS study area (Figure 1.0) includes approximately 483 km (300 mi) of North Carolina coastline. In order to assure a consistent policy founded on the most complete data available, all North Carolina barrier islands were inventoried regardless of their inclusion in ongoing 201 planning efforts. The geographical area considered in the North Carolina Barrier Islands EIS extends from Currituck Banks at the Virginia/North Carolina border to Sunset Beach at the South Carolina/North Carolina border. Currently, six 201 Facilities Plans are under consideration within this area covering about 40 percent of the length of the barrier islands along the state's coast. These plans include Southwestern Brunswick County, Southeastern Brunswick County, Topsail/Surf City in Onslow County, Carteret County Complex, and Hatteras Island and Dare Beaches Complex in Dare County.

Three other 201 Plans include North Carolina barrier islands: Greater Carolina Beach, Greater Wilmington and Swansboro. These plans have been


CURRITUCK SOUND
CURRITUCK
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
KILL DEVIL HILLS
CHOWAN RIVER
ALLIGATOR RIVER
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH

LEGEND

Figure 1.0

STUDY AREA

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

SCALE IN MILES
5 2.5 0 5 10 15 20 30 40

approved by USEPA and are in Step 2 and Step 3 of the 201 Construction Grants Program.

Several issues have been identified as crucial to this EIS. The Environmental Inventory is designed to address these issues as well as those typically conducted by a 201 Facilities Plan EIS. The issues identified are:

1. Water quality--The documenting of existing water quality and sources of water quality problems are critical issues.

2. Alternative wastewater technologies--The range of available technologies for wastewater management on the North Carolina Barrier Islands should be investigated.

3. Financial impact on local governments--The financial impact of operating and maintaining centralized sewer systems by small municipal governments on the barrier islands is a major concern.

4. Non-point source pollution--New wastewater systems may promote higher density development, thus increasing the potential for non-point source pollution of estuarine waters.

5. Groundwater--The potential contamination of shallow groundwater by on-site wastewater management facilities is a major concern. Current and potential use of this resource will be evaluated.

6. Sensitive Natural Areas--The primary and secondary effects of wastewater management facilities on sensitive natural areas, especially wetlands, estuarine waters, and ocean hazard areas, will be addressed in the EIS.

This report is divided into two major sections, the Natural Environment and the Manmade Environment. Both sections, where appropriate, describe historical and current trends as well as future trends.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

THE BARRIER ISLAND ECOSYSTEM IS A NETWORK OF PHYSICAL AND BIOLOGICAL ELEMENTS

Due to their coastal location, barrier islands are exposed to physical influences which are generally more varied and extreme than inland ecosystems in the Southeastern United States. Physical elements which are particularly significant include: waves, currents, floods, tides, water salinities, winds, storms, and soils. Due to the variety of physical influences and habitat conditions, the overall biological diversity of the barrier islands is very high. The marine system contains numerous finfish and shellfish populations, many of which are commercially important. The highly productive estuarine system provides food sources, breeding and nesting areas for most of the aquatic life in all the coastal waters. Terrestrial plant communities are important in stabilizing barrier islands and provide valuable habitat and nesting areas for a number of organisms, particularly birds.

Barrier islands are probably best understood as an ecosystem encompassing the total environment created by interacting processes among physical and biological elements. Important physical elements include water (waves, currents, tides, floods, and salinities), wind, climate and soils. Biological elements include the various plants and animals occurring within the ecological communities of the marine, estuarine, freshwater and terrestrial habitats. Although there is a tendency to view island features as unstable, in a broader consideration the islands exhibit a large degree of dynamic stability especially when compared to the life span of human beings. Although maps document that the configuration of Cape Lookout has changed dramatically within the last century, the total land area has remained nearly constant (Godfrey & Godfrey 1976).

Another important concept pertaining to the barrier islands is the interrelatedness of various environmental components and processes. Although discussions of the physical environment may separate elements such as winds, waves and storms, such elements are intimately related. Even biological and physical components are sometimes difficult to separate, as in the case of soils, which result from the interraction of numerous elements such as groundwater, sediment types, and ground covers.

Variety is an additional concept which applies to many features on the barrier islands. Many physical elements have important effects on the barrier island ecosystem, often varying greatly between different locations and periods of time. With regard to biological features, variety is often expressed in terms of diversity. In ecological terminology, diversity usually refers to the number of species in a particular community or region. Highly diverse ecological communities contain a large number of species, with a relatively even distribution of dominance among the different species. Conversely, low diversity communities contain relatively few species and are usually dominated by a small number of plant and animal species.

Physical Environment

The physical effects of surrounding waters on barrier islands are difficult to overemphasize. Although the coastal waters serve to moderate the general climatic conditions of the coastal region, waves and currents have a continual effect on island configurations and shorelines. The surf and longshore drift alter the shape and location of shoreline beaches and dunes, lead to the movement and closure of inlets, contribute to the gradual migration of islands toward mainland shores and cause vegetation-altering salt spray. The effects of wave action and currents are most pronounced during storm conditions when high winds and low atmospheric pressure create greatly elevated storm surges which flood lower lands and sometimes overwash the islands.

Another effect of water is imposed by tidal changes and elevated water tables. Although the average tidal range of .9 m (3 ft) is relatively low along the North Carolina coast, this factor has a considerable effect on barrier island ecology. Small differences in elevation can result in extreme drainage changes. The influence of tides has led to the formation of extensive saltwater and brackish marshes along the low-lying lands on the inner shores of the barrier islands. Elevated water tables have had a similar but less extensive influence on the formation of freshwater ponds, marshes and swamps in depressions and sloughs.

The general types of shoreline change and structural failures on barrier islands have been consistently repeated over the years. Some degree of gradual continuing long-term erosion is likely. The expected rate varies greatly from place to place, but the average rate is roughly 1 m (3.5 ft) per year. Rates will be considerably higher near inlets and generally independent of dune height.

Existing inlet areas can expect rates of shoreline erosion typically 10-30 m (30-100 ft), sometimes consistently moving in one direction, sometimes fluctuating around a central inland body of water. New inlet formation is a very real threat at a few sites but should not be perceived as a substantial threat to most of the developed areas.

Also associated with coastal waters are differing water salinities, which have a great effect on biological communities. In the transition zone of estuarine sounds varied salinities and sharp gradients create stressful environmental conditions for the associated plants and animals.

Winds are physically important because they contribute to wave action and currents and shift the sandy soils of beaches and dunes. Biologically, the distributions of island vegetation communities are largely determined by the relative tolerance of plants to wind-borne salt spray and sand. In the estuarine and marine communities, winds perform a critical function by mixing and aerating waters.

Major storm impacts are controlled by existing dune development and general topography. During storm events ocean water levels rise on the order of 2-3 m (6-10 ft) above normal high tide. Substantial dune erosion will occur as far as 15-60 m (50-200 ft) landward. Buildings not constructed on a deep piling foundation or not elevated above the waves will be severely damaged or destroyed. If the barrier island or mainland beach has sufficient elevation to prevent overtopping by waves, damage to the highland areas will be relatively low. Localized winds in excess of building design speeds as well as falling trees and flying debris will be the major causes of structural damage.

Two types of major storms have serious effects on the North Carolina coast: northeasters and hurricanes. Northeasters originate in the interior mid-latitudes of the United States and frequently move offshore along the North Carolina coast. These storms build in intensity as they progress along the Atlantic coast, creating high winds, waves and tides. Northeasters are relatively frequent during the winter months and usually occur several times each year. Hurricanes originate in or near the tropical waters of the Atlantic Ocean and develop into major storms as they move westward into the Caribbean Sea or northward up the Atlantic coast. These storms usually occur in late summer and early fall, with September being the most active month. Although they are generally more intense storms, hurricanes are less frequent than northeasters. Based on long-term records, hurricanes affect some portion of the North Carolina coast about one out of every three years, even though the last 20 years have been relatively low in activity.

Well-developed, relatively fertile soils are found only at protected sites on the interior sides of the wider portions of barrier islands and on Roanoke Island. More typically, soils on well-drained sites consist of dry, unstable and nutrient-poor sands. Such soils are easily moved about by winds or flooding water and often limit the growth of vegetation. On poorly-drained sites, soils consist of highly organic and nutrient-poor peats. Such soils are relatively stable and usually are well vegetated by wetland plant communities.

Biological Environment

The moderated maritime climate, assortment of habitat conditions and the variety of physical influences have tended to encourage a high diversity of plant and animal life. Conversely, the isolation of the islands from mainland areas, relatively young geologic age, limited size and the harsh physical environment have tended to limit the abundance and diversity of organisms. As a result of these interactions, the barrier islands and their surrounding waters contain a large number of distinct but interrelated ecological communities, with a correspondingly high total diversity of plants and animals in the region. Within these different communities, however, biological diversity and abundance may vary depending on the severity of environmental influences and the abundance of food sources.

The ecological communities of the islands occur in three major systems: marine, estuarine, and terrestrial. The marine system extends from the Atlantic Ocean to the upper tidal limits of the ocean-front shorelines. The estuarine system occurs in the sounds, bays, rivers and creeks separating the barrier islands from the mainland. The terrestrial system includes the lands located above sea level on the barrier islands. A freshwater system may also be recognized but is included here as a component of the terrestrial system; most freshwater areas are limited in extent and largely intermix with the terrestrial wetland communities on the barrier islands.

The marine ecological system is located in the high salinity waters of the Atlantic shores and the continental shelf. Compared to other aquatic systems, the overall species diversity of marine areas is high, but abundance and density are relatively low. The marine communities support numerous populations of fish and invertebrates, many of which are of commercial importance in the study area. Marine mammals, such as porpoises and whales may be associated with any of the offshore communities.

Estuaries are defined as semi-enclosed coastal water bodies having free connections with the open sea and serve as a transition zone between the high salinity marine waters and the freshwater inland drainage systems. Steep gradients of salinity change create stressful environmental conditions for aquatic life and are largely responsible for the relatively low diversity of estuaries. However, the plants and animals which have adapted to these conditions are exceptionally abundant and productive due to the richness of nutrients and food sources typical of estuaries. The estuarine communities are extremely important because they provide abundant food sources as well as breeding and nursery areas for numerous species of shellfish and finfish, many of which are commercially valuable. According to research conducted in other coastal areas of the Southeast, over 95 percent of the commercial fish catch is in some way dependent on the estuarine system (Juhl 1974).

Seven terrestrial communities may be recognized: dunefields, grass flats, shrub thickets, freshwater marshes, saltmarshes, maritime forests, and swamps. Within each community, the diversity of plants and animals is generally low in relation to comparable mainland areas. However, the overall diversity of the terrestrial system is relatively high because of the varied habitat conditions. Terrestrial communities are usually described in terms of the predominate vegetation patterns because plants are highly visible, relatively stable and largely determine wildlife distributions.

Additionally, vegetational cover plays an essential role in maintaining the stability of barrier island soils and landforms. Terrestrial wildlife populations are generally low in diversity on the offshore islands because of the migration barriers imposed by coastal waters. An exception to this tendency are bird populations, which are particularly abundant and diverse on the barrier islands. Terrestrial communities provide valuable nesting, feeding, and resting areas for many of these birds due to the situation of the barrier islands within the Atlantic Coastal Flyway.

The following sections discuss in detail each component of the natural environment.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.1 Water Resources

SURFACE AND GROUNDWATERS ARE VALUABLE RESOURCES TO THE BARRIER ISLANDS

The surface waters associated with the barrier islands are important to tourism-related activities and to commercial fishing. The northeastern barrier islands rely on the upper sandy aquifer as the major source of potable water. The southeastern barrier islands rely on the deeper limestone aquifer as the major public water supply. A possible resource conflict exists between the use of the shallow acquifer as both a potable water supply and for disposal of treated wastewater from septic tanks or package plants.

The primary surface water resources directly associated with the barrier islands are brackish waters or saltwaters including the estuarine waters on the mainland side of the islands and Atlantic Ocean. Some freshwater ponds are found but hydrologically they are more an extension of the water table than an independent surface water body. Therefore, small freshwater bodies on the barrier islands are not identified as significant surface water resources.

The resource value of the coastal surface waters cannot be overemphasized. They provide recreational opportunities for boating, swimming and sportfishing. In addition, they support an abundance of shellfish and finfish, the basis for a large commercial fishing industry. The importance of the estuarine waters to the food chain, which supports a major proportion of the ocean's finfish, is another primary consideration.

Because of the importance of the resource values cited above, the use of surface waters associated with barrier islands for assimilating treated wastewater is limited. The State of North Carolina prohibits the discharge of wastewaters to SA waters regardless of treatment level (North Carolina Administrative Code Title 15, Chapter 2, Subchapter 2H, Section .0400). Treated wastewaters may be discharged to the ocean in accordance with regulations promulgated by the North Carolina Environmental Management Commission. Ocean discharge sites, however, may be severely limited by locally varying conditions such as the slope of the ocean bottom, depth, distance offshore and currents. The lack of available surface waters for discharge of treated wastewaters limits the applicability of conventional wastewater treatment/discharge systems on barrier islands.

Groundwater is essentially the only supply of freshwater on the barrier islands. Groundwater occurs almost everywhere on the islands, but its availability for use as a water supply is dependent upon the thickness of the fresh water lens. In most places on the barrier islands, saltwater or brackish water is found at such shallow depths that freshwater yields are less than 379 lpm (100 gpm) even when the aquifer is very permeable (Robinson and Mann 1977). The threat of saltwater intrusion at higher pumping rates or longer durations further limits freshwater yield. In the northeast portion

2.1 Continued

of the study area, the major source of freshwater is the shallow, confined and semi-confined upper sandy aquifer. This water source has become brackish in recent years from over use. Use of these shallow aquifers for disposal of wastewater from septic tanks or package treatment plants/soil absorption systems could lead to the contamination of potable water supplies from wastewaters high in nitrates, bacteria, or viruses if systems were improperly installed and maintained.

South of Beaufort Inlet, groundwater is generally not a limiting resource. Most public water supplies are obtained from the deeper limestone aquifer. Additionally, many of the barrier island developments in the southern portion of the study area obtain their water supplies from deep wells on the mainland. No major resource conflicts exist with regard to the deeper freshwater aquifer since North Carolina does not allow deep well injection of wastewaters.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.1 Water Resources

2.1.1 Surface Water Hydrodynamics

HYDROLOGY OF SURFACE WATERS SURROUNDING BARRIER ISLANDS IS COMPLEX

The mixture of saltwater from the ocean and fresh water from inland runoff forms a complex hydrological system. Knowledge of the surface water hydrology is necessary to assess the impacts of wastewater disposal on barrier islands.

The barrier islands, with the Atlantic Ocean on one side and the estuarine waters on the inland side, are situated in the midst of a complex hydrological system. The estuarine waters behind the barrier islands are a mixture of freshwater from inland runoff and saltwater from the tides of the Atlantic Ocean. As described by Clark (1974), the Atlantic Ocean and the freshwater runoff compete for space behind the barrier islands. This competition creates highly variable circulation patterns which are affected by winds, tides and density layers caused by varying temperatures and salinities. The Atlantic Ocean acts as a giant reservoir, a constant source of saltwater pushing against the lighter, more variable inland sources. The ocean flow inland is primarily affected by tide levels, storms and changes in inlet size and location. Freshwater flow is subject to seasonal changes in precipitation and runoff.

The hydrological forces at work in the coastal waters have a major impact on the estuarine ecosystems. The volume of freshwater runoff governs the salinity of estuarine waters as well as the patterns of circulation (Clark 1975). Since salinity ultimately affects the types and abundance of species, the volume of freshwater runoff affects the distribution of life in estuarine waters. The construction of dams or agricultural and forestry practices have a major impact on freshwater runoff. The effects of inland activities on surface water hydrology and ultimately on estuarine ecosystems is illustrated by the depletion of the oyster population in the Lower Cape Fear estuary. This depletion is a result of salinity change caused by increased runoff from land use changes and increased peak flows from stream channelization (Carpenter 1981).

The circulation of the estuarine and ocean surface waters determines where the pollutants from the islands are transported. The coastal waters of North Carolina, river estuaries, bays, sounds, tidal wetlands and the nearshore oceans have been intensively studied. Many of these studies are either directly concerned with the movement and circulation of the surface waters or address hydrology as it pertains to sediment transport or beach erosion. The types of data range from the general hydrology of the major estuaries of North Carolina (Giese, Wilder and Parker 1979) to drogue studies conducted by the Division of Shellfish Sanitation to determine circulation patterns in specific shellfish areas. Because of the complexity of the hydrodynamics of the surface waters within this study area, it is not possible to go into great detail. Appendix 2.1.1.a is a general bibliography of literature reviewing the hydrodynamics of the study area. Additionally, a bibliography of site specific hydrologic studies is contained in Appendix

2.1.1 Continued

Table 2.1.1.b, followed by a reference chart, Appendix Table 2.1.1.c, that correlates the alphabetically arranged sources in Appendix Table 2.1.1.b, to specific water bodies in the study area. This information would prove useful as a basis for conducting detailed hydrodynamic studies on a site specific EIS.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.1 Water Resources

2.1.2 Surface Water Quality

MAJOR PROBLEMS EXIST WITH SURFACE WATER QUALITY

North Carolina has established water quality standards and guidelines to manage its surface waters. Ambient water quality monitoring stations are maintained to identify long term trends in water quality. Additional monitoring is also conducted in shellfish waters. Most waters within the EIS study area are classified as shellfish waters. Total coliform bacteria is the key parameter used to open or close these waters to the harvesting of shellfish so as to minimize public health risks from the consumption of contaminated shellfish. Approximately 46,193 ha (114,058 ac) of shellfish waters within the study area are currently closed to harvesting. Additional water quality problems within the study area result from decreased salinity, increased nutrient concentrations and heavy metals violations.

General water quality standards have been established for the intracoastal and coastal waters of North Carolina. Tidal waters have been classified by intended use and assigned additional water quality standards. Most waters within the EIS study area are classified as shellfish waters. Although not legally binding, water quality guidelines have also been established as a means of identifying pollution problems before they have reached a crisis stage.

Ambient water quality monitoring stations have been established as a means of identifying long term trends in water quality. A portion of each site is designated as a CORE station and is used by USEPA to assess nationwide trends in water quality. Monitoring is conducted by the North Carolina Division of Environmental Management. The most frequently violated parameters noted from monitoring sites within the EIS study area include total Kjeldahl nitrogen, ammonia, total phosphorus, BOD_5, total coliform, total mercury, total lead, total zinc, and total cobalt.

The North Carolina Department of Human Resources, Division of Health Resources, Shellfish Sanitation Office conducts sanitary and shoreline surveys of all shellfish waters once every two years. The sanitary survey is primarily concerned with identifying high bacterial counts, while the shoreline survey identifies the possible origin of such counts. If high bacterial counts are found and attributed to fecal material of humans, other warm blooded animals or waterfowl, these waters may be closed to further harvesting of shellfish until the bacterial counts can be brought under control.

High total coliform bacterial counts indicate the possibility of disease-causing agents which, when concentrated in shellfish and then consumed by man, could result in a disease outbreak. As of January 1981, approximately 46,193 ha (114,058 ac) within the EIS study area have been closed to shellfish harvesting.

2.1.2 Continued

Additional water quality problems include decreases in salinity, increases in nutrient levels, and to a lesser degree, heavy metal violations. Decreases in salinity result primarily from mainland land use changes and reduce the productivity of primary nursery grounds and shellfish waters. Increases in nutrient levels occur from mainland land use changes and cause algal blooms, dissolved oxygen violations, fish kills and increases in red sore disease among fish. Although heavy metals violations occur, they are not felt to be a major problem at this time.

NORTH CAROLINA HAS ESTABLISHED WATER QUALITY STANDARDS AND GUIDELINES

Water quality standards have been established for North Carolina's intracoastal and coastal waters. These waters are also protected with additional standards according to their uses: shellfish, bathing and fish propagation. The majority of the waters within this EIS study area are shellfish waters which are also subject to federal bacterial standards. The North Carolina Division of Environmental Management has also issued a set of water quality guidelines as a management tool in assessing the environmental health of its surface waters.

Water quality standards for North Carolina's intercoastal and coastal waters are contained in the North Carolina Administrative Code, Title 15, Department of Natural and Economic Resources, Chapter 2, Section 0.0200. (Appendix Table 2.1.2.1.a). Tidal waters are classified by their intended best usage and are assigned additional water quality standard classifications to protect the defined best usage. North Carolina tidal water classifications and their assigned best usages are as follows:

Classification	Best Usage	Standards
SA	Shellfishing for market purposes and any other usage specified by the SB or SC classification	Appendix Table 2.1.2.1.b
SB	Primary recreation (bathing) and any other usage specified by the SC classification	Appendix Table 2.1.2.1.c
SC	Fishing, secondary recreation (wading) and any other usage except for primary recreation or shellfishing for commercial purposes	Appendix Table 2.1.2.1.d

Most of the waters in the study area are classified SA. Water quality standards for these waters are the most stringent. Exceptions include Currituck Sound and the Cape Fear estuary, the immediate vicinity of wastewater treatment plant outfalls which are classified as SC waters, and the Atlantic Ocean which is designated as SB waters.

An additional federal standard for shellfish waters with respect to fecal coliform bacteria is described as follows:

- Fecal coliform group not to exceed a median MPN (most probable number) of 14/100 ml

2.1.2.1 Continued

- Not more than 10 percent of the samples shall exceed an MPN of 43/100 ml

This standard is not used to open or close shellfish beds in North Carolina. However, it is used as a guideline by state shellfish experts in assessing the quality of SA waters. Many scientists consider the federal fecal coliform standard more relevant than the total coliform standard for opening or closing shellfish beds to prevent outbreaks of disease from enteric bacteria (Morris 1981). Nevertheless, opening and closing shellfish beds based on either of the above two bacterial standards has resulted in a major decline in disease outbreaks associated with bioaccumulation of enteric bacteria by shellfish.

In addition to water quality standards which are legally binding, the North Carolina Division of Environmental Management has issued a set of water quality guidelines. Though not legally binding, these water quality criteria provide insight into water quality violations that could have adverse environmental impacts on the aquatic ecosystem. In most instances, guidelines have been established where no water quality standards exist. Where standards exist, guidelines have been established which are stricter than the standards. The purpose of these guidelines is to enable the Division of Environmental Management personnel to identify a potential water quality problem, to investigate the cause of the problem and to remedy the situation before a crisis develops. A comparison of State Standards and Guidelines with USEPA recommended criteria for water quality parameters most violated in the waters of this EIS study area is contained in Appendix Table 2.1.2.1.e. In a few instances these guidelines are less strict than the USEPA criteria. These exceptions include:

- Ammonia nitrogen - USEPA criteria for ammonia nitrogen is based upon the toxic un-ionized portion of this parameter which is closely related to pH and temperature. The North Carolina guideline is based on total ammonia nitrogen. The pH and temperature of the water being tested must be known to determine the concentration of toxic un-ionized ammonia nitrogen represented by this concentration.

- Iron. The total iron guideline of 1000 ug/l is well in excess of the 50 ug/l concentration determined by USEPA to be hazardous for marine life.

- Lead. The total lead guideline of 100 ug/l is in excess of the 50 ug/l concentration determined by USEPA to be hazardous for marine life.

- Nickel and Manganese. The total nickel and manganese guidelines of 100 ug/l are on the borderline of being considered hazardous based upon USEPA criteria. These guidelines need to be lower if the purpose is to identify a potential problem before it has reached a crisis.

NORTH CAROLINA PROVIDES AMBIENT WATER QUALITY MONITORING

Ambient water quality stations provide a network of sites to assess long term trends in the waters of North Carolina. Budgetary and manpower restrictions combined with a limited number of sampling sites and monthly surveys have reduced the effectiveness of this water quality monitoring effort.

The State of North Carolina maintains a network of monitoring stations to assess long term trends in water quality. Some of these monitoring sites are also designated as CORE stations. CORE stations are used by the USEPA to assess nationwide trends in water quality. This information is stored on USEPA's computerized water control information system, STORET.

Records of violations of water quality guidelines and standards from January 1978-January 1981 were obtained from the Division of Environmental Management for ambient network stations in and around the barrier islands (Appendix Table 2.1.2.2). In general, water quality appears to be good in and around the barrier islands. The most frequently violated parameters are total Kjeldahl nitrogen, ammonia, total phosphorus, BOD_5, total coliform, total mercury, total lead, total zinc and total cobalt. Violations appear more frequently north of Morehead City. No attempt is made in this report to determine the cause of violations, only to recognize that violations occur in estuarine waters around the barrier islands.

Division of Environmental Management personnel have explained that budgetary and manpower restrictions combined with a limited number of sampling sites and monthly surveys have reduced the effectiveness of this water quality monitoring program. This situation is not expected to improve in the immediate future.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.1 Water Resources

2.1.2 Surface Water Quality

2.1.2.3 Monitoring Criteria for Shellfish Waters

MONITORING OF SHELLFISH WATERS IS CONDUCTED FOR PROTECTION OF PUBLIC HEALTH

Water quality monitoring of shellfish waters is conducted by the North Carolina Department of Human Resources, Division of Health Services, Shellfish Sanitation Office. The two key tools to monitoring and managing North Carolina's shellfish waters are the shoreline surveys to identify possible pollution sources and sanitary surveys to collect data on coliform bacteria levels in shellfish waters. Coliform bacteria indicate the possible presence of human fecal material which could contain disease organisms from infected persons or animals. Recent research indicates that certain bacteria and viruses may better correlate with fecal coliform counts in sediments than with either total or fecal coliform counts in overlying surface waters.

Approximately 823,314 ha (2,032,875 ac) of shellfish waters are located within the boundaries of North Carolina. As of January 1981, approximately 132,876 ha (328,088 ac) (16.1 percent) were closed to shellfishing. Approximately 46,193 ha (114,058 ac) (20.8 percent) of closed shellfish waters out of a total of 222,609 ha (549,653 ac) of shellfish waters within the EIS study area have been closed due to high coliform bacterial counts. These closed shell waters are displayed in the Atlas, Water Resources Map.

Shellfish waters were originally classified according to suitability of bottom habitat and overlying surface water salinity. However, not all shellfish waters support viable populations of commercially harvestable shellfish. In many cases, a lack of clutch material (old oyster shells) exists for the laval oysters (spat) to settle and grow upon. The state's shell planting program could make such waters productive by placing old shells on the bottom. However, manpower and funding limitations restrict this form of management to only those shellfish waters that are currently open. In some instances opening of currently closed shellfish waters could provide commercially harvestable quantities of shellfish. Very little has been done to date to assess the existing or potential production of opened and/or closed shellfish waters. The only study date, by Godwin (1977) estimated that the 1,721 (4,250 ac) of closed shellfish waters in Brunswick County contained 76,992 U.S. standard bushels of oysters and 4.0 million clams.

Sanitary surveys are conducted once every two years by the N.C. Department of Human Resources, Division of Health Services, Shellfish Sanitation Office. The shellfish waters are divided into management units, and a number of sampling stations have been established within each management unit. Monitoring of bacteriological, water quality, salinity and meterological conditions takes place during the survey. At each sampling station grab

2.1.2.3 Continued

samples are randomly collected over a six to nine month period. This effort typically results in 10-13 bacterial samples per station. During the period between sanitary surveys, an attempt is made to sample representative stations from within each management unit once every two or three months. Additionally, if the sanitary survey or the routine monitoring data indicates possible degradation of open shellfish waters and/or the improvement of closed shellfish waters, a special study will be undertaken. Usually, this special study would take place under worst state conditions, such as after a rain event, and sampling would take place over a two to three day period to provide 7-12 samples per monitoring station at both high and low tide. Samples are analyzed for total and fecal coliform. Results are compared with the State bacterial standards (Appendix Table 2.1.2.1.b).

Total coliform bacterial counts are supplemented with shoreline surveys, which indicate possible sources of pollution. During these surveys, personnel from the Shellfish Sanitation Office walk the shoreline of a given management unit and identify possible sources of bacterial contamination such as barn yards, failing septic tanks, marinas, municipal or industrial sewer outfalls, storm sewer outfalls and ground disturbing activities.

Total coliform bacterial counts, along with sources of pollution, are the key factors in determining whether shellfish waters should be opened or closed to harvesting. Coliform bacteria are found in the intestinal tracts of humans and other warm blooded animals. However, some coliform bacteria can exist free-living in soils and on terrestrial and aquatic vegetation, causing high total coliform counts even though there is no direct contamination from fecal material. Therefore, the origin of contamination, as indicated by the shoreline survey, is important.

Coliform bacteria are only indicator organisms and are generally harmless. However, they indicate the possible presence of fecal material which could contain disease causing organisms from infected humans or other warm blooded animals.

Fecal material from heavy waterfowl populations can result in high coliform counts. This fecal material may contain salmonellae and possibly other enteric organisms that could bioconcentrate in shellfish (Morris 1981). It is believed, however, that fecal material from waterfowl contains few human disease-producing organisms and a lower chance for human contamination is associated with a reservoir-vector-host transmission from waterfowl-shellfish-man compared to the route of man-shellfish-man (Benton 1981). For this reason, shellfish beds may be allowed to remain open until total coliform counts exceed an MPN of 93/100 ml in areas where waterfowl populations are believed to be the cause, while normally shellfish waters are closed at an MPN of 70/100 ml.

According to recent studies by Sobsey (1980) certain human enteric disease-causing bacteria such as Vibrio spp. and viruses such as hepatitis do not correlate well with total and fecal coliform indicators as measured in surface waters (Carrick 1981). This research indicates that viruses may or may not be present in waters that are open to harvesting based on total and fecal coliform counts. However, the fecal coliform counts in sediments may serve as a useful indicator of virus levels in oyster meats or as a threshold after which oyster meat should be evaluated for possible viral contamination.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.1 Water Resources

2.1.2 Surface Water Quality

2.1.2.4 Fundings of Studies Addressing Bacterial Contamination of Shellfish Waters

SOURCES OF BACTERIAL CONTAMINATION OF BARRIER ISLAND SHELLFISH WATERS ARE DIVERSE AND DIFFICULT TO IDENTIFY

Septic tank/soil absorption systems, urban runoff and marinas are potential sources of bacterial pollution to barrier island shellfish waters. Data from previous studies are site specific and of limited value when considering the overall barrier islands area. The sanitary surveys of shellfish waters conducted by the Shellfish Sanitation Office may provide some insight regarding the origins of shellfish water contamination near barrier islands.

The map of closed shellfish waters displayed in the Atlas, Water Resources Map indicates that most of the approximately 46,193 ha (114,058 ac) of closures within the EIS study area result from pollution originating from the mainland. Although the amount of closed shellfish waters attributable to contamination from barrier islands is small compared to the total closures, it is by no means considered insignificant. A major concern is the question of the extent to which septic tank and soil absorption systems contribute to contamination of groundwater and surface waters of the barrier islands. In addition, there is concern that runoff from high density sewered areas may cause as much contamination as the existing unsewered areas.

Although septic tanks are thought to cause contamination of barrier island waters, relatively little data are available to confirm or deny this claim. Those studies that have been made deal with specific locations and are of limited value for making generalizations for all barrier islands. Specific studies include work by Bane and Walker (1980), Shiver and Register (1978), and USEPA (1975).

Bane and Walker (1980) were primarily concerned with pollution from marinas between Southport and Shallotte Inlet, N.C. This study concluded that marinas were contributors to coliform pollution of shellfish waters in Brunswick County. Another important finding was that increasing total and fecal coliform counts were associated with rainfall, since elevated bacterial counts in shellfish waters were generally observed after rainfall. There was no attempt to determine the sources of this pollution other than the marinas.

Pollution of shellfish waters as the result of boat harborage and discharge of marine toilets (heads) in and around marinas is a threat in North Carolina. As of January 30, 1980 all boats in coastal US waters with heads were required by law to have at least a Type I (Mascerator/chlorinator for disinfection) device. This excludes boats with "portapotties" or vessels

2.1.2.4 Continued

with no heads. This law is enforced by the U.S. Coast Guard. However, it is difficult to enforce the law effectively due to the widespread nature of the problem.

Additionally, the State of North Carolina requires all new marinas and existing marinas which apply for updating of permits to install a pump-out station so that docked boats can empty their toilets without discharging into the surrounding waters. The State requires a closed head for all boats while docked at the marina. However, this policy is not being enforced due to budgetary limitations and manpower allocations. DNRCD staff who conducted a survey of a marina around Beaufort, N.C. found the pump-out station being used on the average of only 2-3 times per month (Schmidt 1981). If this practice is typical of other marinas throughout North Carolina barrier island marinas, the problem is significant.

Shiver and Register (1978) and USEPA (1975) analyzed total and fecal coliform contamination originating from septic tanks on finger fill canals at Surf City. Rhodamine dye studies indicated a dual transport mechanism of total coliform bacteria originating from septic tanks into shellfish waters:

1. Direct transport of bacteria and other pollutants through the groundwater (surficial aquifer) to the shellfish waters

2. Indirect transport overland during periods of moderate to intense rainfall (0.28-0.76 cm/hr) (0.11-0.30 in/hr) when rising ground water levels force contaminated waters in soil absorption systems to the surface

A conclusion of the study is that direct transport is of minor concern, since it appeared that the septic tank systems adequately filtered out bacteria, causing their counts to be extremely low in the groundwater, generally less than 3/100 ml for both total and fecal coliform. Under normal operating conditions, conventional septic tanks appeared to provide adequate removal of bacteria from the septic tank leachate. The study reports that under dry weather or low rainfall conditions, direct transport of bacteria to shellfish waters was of little concern since, prior to entering the surface waters, bacterial counts were well below those considered dangerous for shellfish waters.

Surface runoff or indirect transport of contaminated waters resulted in total coliform counts ranging from 22,100-240,000 MPN/100 ml and fecal coliform counts from 330-13,000 MPN/100 ml in shellfish waters immediately adjacent to the runoff. The Surf City study may or may not apply to other finger fill canals along the barrier islands of North Carolina.

The key factor in controlling bacterial levels in groundwater and adjacent shellfish waters, appears to be the coarseness of the soil material between the nitrification field and ground water table. Fine to medium grain materials typically result in low bacterial counts in the groundwater while a medium to coarse material will generally produce higher counts (Shiver 1981). In the case of Surf City, most of the fill material was adequate to reduce groundwater levels of bacteria. However, each area developed by filling-in marsh must be analyzed separately as to its fill material in order to determine its suitability for placement of septic tanks that will adequately remove bacteria prior to the leachate's contact with groundwater. Future development using septic systems should carefully select fill materials.

The second key issue is the geological/hydrogeological conditions of the site. On finger fill canals, a natural hardpan layer of marsh is typically filled in with man-made materials. Break outs of the groundwater aquifer in such areas may occur when rainfall saturates the soils. Since vertical migration of rain waters is limited by the impermeable pan, the soil absorption site is saturated and overflows to the surface. The type of on-site system that functions safely under such circumstances is addressed in Appendix 3.3.3.

Because the above findings are obtained from site-specific studies, it is difficult to draw general conclusions regarding the causes of bacterial contamination in barrier island shellfish waters. To date, there has been no attempt to identify the extent of contamination of shellfish waters by malfunctioning septic tanks on barrier islands.

An important source of information that may provide some insight into the causes of pollution are the sanitary surveys and shoreline surveys (Section 2.1.2.3). During these surveys, only obvious causes of pollution are mentioned such as direct discharges into shellfish waters from washing machines or from septic tanks that by-pass the nitrification field. Typically, sanitary surveys are limited by time and money and cannot always be undertaken under worst state conditions such as during or just after heavy rainfall when septic tank leachate could be forced to the surface. Additionally, such malfunctions may not always be readily observable, requiring special dye tests to be visually discernable.

Despite any limitations, the sanitary surveys provide the most extensive data base available for studying the general locations and possible causes of barrier island shellfish water contamination. To develop some general conclusions regarding shellfish water contamination, this report included a review of the bacteriological water quality data from the 1978-79 sanitary surveys. These data, for certain selected sewered and unsewered areas, are used in conjunction with rainfall data and land use information in an attempt to identify the general causes of shellfish contamination.

The general conclusions from this analysis are summarized as follows:

- High total and fecal coliform counts in shellfish waters around the barrier islands tend to be associated with rainfall events. However, not all rainfall events on the day of or just prior to sampling produced high bacterial counts in shellfish waters.

- High total and fecal coliform counts are typically found below wastewater treatment outfalls from sewered areas. This raises the question as to how well some of these facilities are functioning.

- Discharging of marine toilets by docked boats at marinas up and down the barrier islands appears to be a major contributor to the closure of shellfish waters.

2.1.2.4 Continued

- South of Morehead City the estuarine area is extremely narrow. High flushing rates and the barrier islands' proximity to the mainland makes identification of the cause and origin of bacterial pollution in shellfish waters very difficult to ascertain.

- The sewered areas of Morehead City and Beaufort have few problems, with high bacterial counts being primarily associated with industrial docks and marinas.

- The unsewered areas of Atlantic Beach and the town of Hatteras suffer from high bacterial counts. These are possibly attributable to marinas and to septic tank malfunctions. Waterfowl around Hatteras may also contribute to the bacterial counts.

- High bacterial counts along Hatteras Island from Buxton to Avon appear to be associated with the small towns all of which are on septic tanks. How much of this bacterial pollution is due to malfunctioning septic tank systems or other non-point sources, including fecal material from domestic animals or from water fowl that concentrate near the towns to feed, cannot be determined with available data.

  Data supporting these general conclusions are found in Appendix 2.1.2.4.

2.1.2.5 Heavy Metal Contamination

LIMITED HEAVY METAL CONTAMINATION REPORTED NEAR WASTEWATER TREATMENT PLANT DISCHARGES

Contamination of estuarine waters with cadmium and mercury has been identified in the immediate vicinity of municipal wastewater treatment plant outfalls in coastal waters. Areas removed from wastewater treatment plant appear to be relatively free of heavy metal pollution, although some heavy metals concentrations in excess of water quality guidelines have occasionally been found at ambient water quality monitoring stations (Section 2.1.2.2).

Based upon studies of municipal wastewater treatment plant effluent discharges at Wrightsville Beach and Morehead City, Whaling et al. (1977) concluded that any coastal municipality discharging effluent into tidal estuaries will produce a zone of elevated toxic trace metals, especially mercury and cadmium, in the sediment and in detrital feeding organisms such as the mud snail (Ilyamassa obsoletus). According to Whaling's findings, accumulation of metals in these organisms apparently requires direct ingestion of the contaminated sediment. This finding is based on experimental work with oysters and scallops (filter feeders), shrimp (scavengers) and mud snails (browsers) in which only the detrital feeding snail accumulated significant quantities of mercury when exposed to contaminated sewage sludge. Initial results indicate that no accumulation of metals occurred in the commercially important oyster, thus minimizing the public health risks to man. However, concern exists that lesser understood lethal or sublethal effects on environmentally sensitive organisms could occur from discharging treated effluent from municipalities into intercoastal waters.

Other than this source of heavy metals contamination, which is very localized, Whaling (1981) believes the intracoastal and coastal waters of North Carolina are relatively free of heavy metals pollution. He further indicates that heavy metals accumulation in water birds, whose food sources are often tied to the aquatic ecosystem, and in pelagic fish is believed to be natural. Museum specimens of fish 50-100 years old compared with modern pelagic fish appear to have similar levels of heavy metals in their tissues.

However, some heavy metals concentrations in excess of water quality guidelines have been detected at ambient water quality monitoring stations (Section 2.1.2.2). Heavy metals violations include total mercury, total lead, total zinc and total cobalt (Appendix Table 2.1.2.2). The impacts of these higher metals concentrations are unknown.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.1 Water Resources
2.1.2 Surface Water Quality
2.1.2.6 Nutrients

NUTRIENT POLLUTION CAUSED PRIMARILY BY MAINLAND ACTIVITIES

The primary sources of nutrient pollution in North Carolina's intracoastal waters are related to mainland activities and include runoff as well as municipal and industrial wastewater discharges. A presently unquantifiable amount of nutrient pollution is contributed from wastewater treatment plant outfalls and improperly placed septic tanks located on the barrier islands. Nutrient pollution results in algal blooms, low dissolved oxygen levels, fish kills and outbreaks of red-sore disease in fish. The major areas affected by nutrient pollution are the Pamlico and Albemarle Sounds.

Nutrient pollution has increased primary production and algal populations beyond the assimilative capacity of some of the estuarine areas. This has resulted in increased diurnal oxygen fluctuations, at times causing loss of oxygen in the water column and kills of commercially important fish in a number of instances.

Albemarle Sound. Between 1970-1974 Bowden et al. (1977) found that total phosphorus concentrations in Albemarle Sound continually exceeded the safe limit of .086 mg/l (as P) in which eutrophic conditions are likely in an estuary. Associated with eutrophic conditions are algal blooms, wide diurnal fluctuations in oxygen concentrations and possible fish kills (Ketchum 1969). Esch and Hazen (1980) found that phosphorus concentrations in 87 percent of the water samples collected from Albemarle Sound between 1977-1979 exceeded .05 mg/l (as P), and in their opinion, indicated eutrophic conditions.

With increased concentrations of total phosphorus-P and orthophosphorus-P, the bacteria Aeromonas hydrophila monitored between 1976 and 1979 began exceeding densities of 1000 colony forming units/ml in July 1979. Prior to this time they did not exceed 400 cfu/ml. Corresponding with the increased bacterial levels was a massive outbreak of red-sore disease, caused by these bacteria, in several species of game and commercially important fish. Esch and Hazen (1980) indicate that high summer temperatures and nutrient enrichment caused algal blooms and, in turn, high concentrations of total organic carbon in the water column. This resulted in increased planktonic and bacterial respiration, depressing dissolved oxygen levels, stressing the fish, thus making them susceptible to the red-sore disease. Red-sore disease can result in massive fish kills. In addition, fish with red sore disease are unmarketable due to their deteriorated condition and unsightly appearance. Red-sore disease has been found on fish taken near the barrier islands.

Fish kills are becoming more frequent in western Albemarle Sound. They are associated with nutrient enrichment, algal blooms and depressed oxygen levels. The decline in major commercial fish stocks of Albemarle Sound including American shad, hickory shad, alewife, river herring, striped bass, white perch, catfish and the American eel is associated with pollution from the mainland side of the Sound. Additional research is on-going to assess the possibility of other factors resulting in these fish stock declines.

Western Pamlico Sound. Hobbie and Smith (1975) in their study of the Neuse River Estuary discussed the problems of 1)nutrient enrichment originating from agricultural and urban runoff and 2) point source discharges of municipal and industrial treatment plants. Phosphorus appears to be over abundant in the Neuse River as total phosphorus exceeds the criteria of 86 ug/l-P (as P) 75 percent of the time in the Neuse River. Nitrate appears to be the limiting factor to algal growth in the Neuse and Pamlico Rivers, restricting algal blooms in the estuary to the winter and spring months when rains leach nitrate from the soils in sufficient quantity to reach the estuary prior to being assimilated by plankton.

Drainage controls have been investigated to reduce nitrate loss from agricultural lands (Gilliam et al. 1978). Deoxygenation in the Neuse estuary typically occurs in the bottom waters during the saline stratification of the summer months when nitrate in the estuary becomes limiting and algal blooms are not a problem. This phenomenon forces fish out of the estuary. This deoxygenation is believed to be the residual effect of decaying algae settled from earlier blooms and from organic material washed into the estuary from land. It is not known if this was a natural phenomena prior to man's modification of the Neuse River drainage basin.

Recent discussions with fishery biologists of the Division of Marine Fisheries indicate that fish kills are becoming more frequent in the Neuse and Pamlico Rivers and their estuaries (Sholar and Harwell 1981). This implies increased eutrofication, algal blooms and increased organic loadings that are surpassing the assimilative capacity of western Pamlico Sound. Additionally, outbreaks of red-sore disease are becoming more prevalent, also indicating increased eutrofication.

Nutrient Pollution From Septic Tank Use on the Barrier Islands. The only major study of nutrient pollution resulting from man's use of the barrier islands was conducted at Surf City, North Carolina (USEPA 1975, Shiver and Register 1978). The study concentrated on identifying pollution from septic tanks located on finger fill canals. This study found that nitrogen compounds, total phosphorus and total organic carbon exceeded background counts in groundwaters and surface waters in proximity to the septic tanks. Contamination of the ground water is attributed to the fact that the septic tank drain field was placed directly into the aquifer, since with little or no separation between the nitrification field and the ground water table, adsorption of nutrients by soil particles is very poor (Shiver 1981). A key to successful removal of these nutrients from septic tank leachate appears to be the vertical distance between the nitrification field and the groundwater table although soil coarseness is probably even a greater factor.

In the Surf City study, nutrient pollution of surface waters was found to occur directly through transfer of polluted groundwater to the estuarine

2.1.2.6 Continued

waters, and indirectly by runoff during moderately intense rainfall (0.28-0.76 cm/hr) (0.11-0.30 in/hr). Additional study is required to ascertain how common this form of nutrient pollution is on the barrier islands and coastal mainland of North Carolina. Since finger fill canals and other marsh fill development along the barrier islands are very common, concern exists that nutrient pollution from this source may be widespread.

The only reported fish kills attributed to pollution from barrier islands are isolated occurances indirectly caused by nutrient enrichment. During the summer months algal blooms and/or respiration in bottom sediments result in oxygen depletion in dredged canals on barrier islands, periodically causing local fish kills (Adams 1981). Based on general conversations with personnel from the N.C. Department of Natural Resources and Community Development, nutrient pollution from mainland activities is considered a much more significant problem than nutrient pollution from the barrier islands.

CHANGES IN LAND USE ON MAINLAND HAVE DECREASED SALINITIES IN ESTUARINE WATERS

Salinity is being decreased by changes in land use, resulting in the die-off of oyster beds and decreased secondary productivity of nursery grounds, especially for the brown shrimp, blue crab and northern flounder in the Pamlico sound.

Currituck Sound. Salinity decreases in Currituck Sound are primarily due to a lack of salt water exchange, rather than mainland runoff. This is a result of the natural closing of the Currituck inlet by a storm in 1888 (Pilkey, Neal and Pilkey). However, dune stabilization projects begun in the 1930's have also contributed by reducing overwash and inlet formation. The gradual decrease in salinity has apparently resulted in a displacement of native grasses by Eurasian milfoil. This species shift has, in turn, provided one of the best waterfowl habitats in North Carolina where an estimated one-third of the over-wintering waterfowl in the State reside. It has also provided excellent freshwater gamefish habitat, particularly for largemouth bass. However, this decrease in salinity has essentially eliminated the commercial fishing industry in Currituck Sound. Fishermen, displaced south into Pamlico Sound, have caused increased competition for the resources in that body of water (Barcliff and Foster 1981). Many commercial fishermen are proposing to have an opening cut through the Currituck Banks so that sound salinities can be increased. This proposal is being opposed by waterfowl experts and sportfishermen who fear this action will destroy waterfowl and sportfish habitat.

Pamlico Sound. A major concern of state biologists managing the fisheries of Pamlico Sound is the effect of interior land use changes and channelization on salinities in western Pamlico Sound. Sholar (1980) has correlated historical salinity data with interviews of longtime commercial fishermen and has concluded that, as salinities decreased, so did the number of viable commercially-harvestable oyster beds. It is estimated that oyster beds have receded presently ten miles further downstream as the result of gradual salinity changes in the Pamlico and Neuse Rivers over the last 30 years.

Recent work by Jones and Sholar (1981) indicates a decrease in secondary production in primary nursery grounds draining corporate farms in the area of Rose Bay when compared to water bodies draining naturally-forested areas on the Albemarle/Pamlico Peninsula. The major decrease in production has been for the salinity dependent species of brown shrimp, blue crab, spot, croaker and northern flounder. It appears that decreasing salinities are either causing death of these juvenile and larval organisms or forcing them into less suitable grounds where they are more susceptible to predation. The oyster fishery in Rose Bay, one of the most productive commercial oystering grounds in the state, has also degenerated in recent years as a result of reduced salinities.

2.1.2.7 Continued

Some of the literature appears to contradict, but in reality supports, the above findings. Kirby-Smith and Barber (1979) found that drainage from the Open Grounds Farm, Inc. of Carteret County primarily affected only surface salinities. Kuenzler et al (1977) found that in streams channelized for agricultural purposes, the salinity (conductivity) actually increased. However, Skaggs et al (1980) found peak runoff rates occurred earlier and were three to four times higher on coastal lands developed for agriculture versus similar lands left in a natural state. Therefore, even though salinities of channelized streams in agricultural areas may increase, increased peak flows into the estuaries during heavy rains can result in a sudden drop in salinities of primary nursery grounds due to dilution of the estuarine waters. Kirby-Smith (1981) stated that, in his opinion, these impacts are not due to just one factor, but to the combination of multiple agricultural drainage schemes throughout the entire coastal plain, channelization of the major waterways such as the Neuse and Pamlico Rivers and interior urbanization of the Piedmont Region and coastal plains. All of these factors act together, especially during the heavy spring rains when juvenile fish and invertebrates are moving into the nursery grounds of western Pamlico Sound. Peak flows over the years have increased, resulting in a gradual diminution of salinity during this critical time of the year.

Cape Fear River and Sound. Although most of this area is presently closed to oystering, the oyster population has apparently been greatly reduced due to salinity changes caused by interior land use changes and channelization which occurs from the mouth to Fayetteville (R. Carpenter 1981). Data generated by the U. S. Army Corps of Engineers indicates that channelization has caused an increase in salinity for this area (Long 1981).

2.0 Description of the Natural Environment
2.1 Water Resources
2.1.3 Groundwater Hydrology

THREE MAJOR AQUIFERS UNDERLIE THE NORTH CAROLINA COASTAL PLAIN

The three major aquifers in the North Carolina coastal plain are the upper sandy aquifer, the limestone aquifer and the lower sandy aquifer. The upper sandy aquifer includes the water table aquifer as well as deeper confined aquifers. The groundwater regime of the barrier islands consists of a lighter freshwater lens floating atop the heavier salt water. The supply of high quality groundwater as well as the depth and thickness of aquifers are highly variable.

The three major aquifers in the North Carolina coastal plain region are the upper sandy aquifer, the limestone aquifer, and the lower sandy aquifer. A generalized hydrogeologic cross-section illustrating these formations is provided in Figure 2.1.3.a. The upper sandy aquifer consists of the youngest sediments, primarily sands and clays, together with some limestone and mollusk shells. Fresh water is easily accessible in this aquifer. The upper sandy aquifer is the only groundwater source on the northeast barrier islands. The limestone aquifer lies directly beneath the upper aquifer. It is too deep and brackish to be used for a water supply in northeast North Carolina; however, the limestone aquifer (the Castle Hayne aquifer) provides freshwater to barrier island areas in southeastern North Carolina. The lower aquifer consists of the oldest sediments and is the deepest and thickest of the three. It is not used as a water supply near the barrier islands.

Each aquifer consists of complex beds of different materials. Many of the individual beds that form the aquifers are not continuous from one well to the next (Wilder, Robison and Lindskov 1978). For this reason, the availability of fresh groundwater varies from site to site.

The fresh groundwater reservoir in the upper sandy aquifer on the barrier islands consists of 1) a water table aquifer extending from the land surface to the first confining beds of silt and clays and 2) deeper, confined or semi-confined aquifers beneath and between the silt and clay confining beds. An idealized section of a typical barrier island upper sandy aquifer groundwater system is provided in Figure 2.1.3.b. Essentially, the groundwater regime consists of a lens of lighter freshwater floating on heavier salt water.

Recharge of the water table aquifer is by rainfall. Most rainfall enters directly into the water table aquifer with little or no surface runoff. Recharge of the lower confined aquifers may occur from the water table aquifer where there is sufficient head to force freshwater downward through the confining beds; however, the recharge areas of the limestone and lower aquifers are located primarily on the mainland.

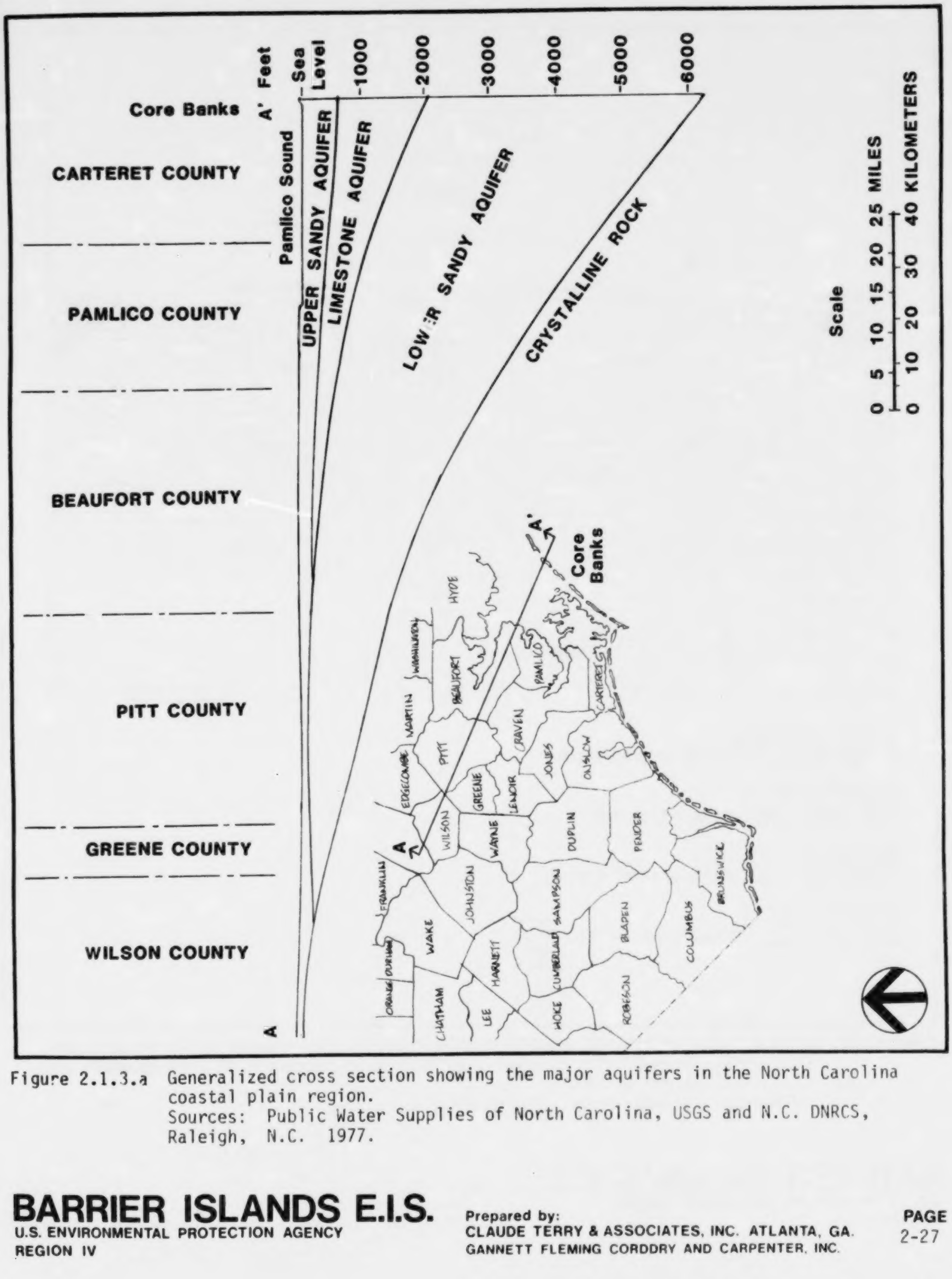

Core Banks
A'
Feet
Sea Level
-1000
-2000
-3000
-4000
-5000
-6000
CARTERET COUNTY
PAMLICO COUNTY
BEAUFORT COUNTY
PITT COUNTY
GREENE COUNTY
WILSON COUNTY
A
Pamlico Sound
UPPER SANDY AQUIFER
LIMESTONE AQUIFER
LOWER SANDY AQUIFER
CRYSTALLINE ROCK
Scale
0 5 10 15 20 25 MILES
0 10 20 30 40 KILOMETERS
A'
Core Banks
A
HYDE
WASHINGTON
MARTIN
BEAUFORT
PAMLICO
EDGECOMBE
PITT
CRAVEN
CARTERET
GREENE
LENOIR
JONES
ONSLOW
WILSON
WAYNE
DUPLIN
PENDER
FRANKLIN
JOHNSTON
SAMPSON
BRUNSWICK
WAKE
HARNETT
CUMBERLAND
BLADEN
COLUMBUS
DURHAM
ORANGE
CHATHAM
LEE
HOKE
ROBESON

Figure 2.1.3.a Generalized cross section showing the major aquifers in the North Carolina coastal plain region.
Sources: Public Water Supplies of North Carolina, USGS and N.C. DNRCS, Raleigh, N.C. 1977.

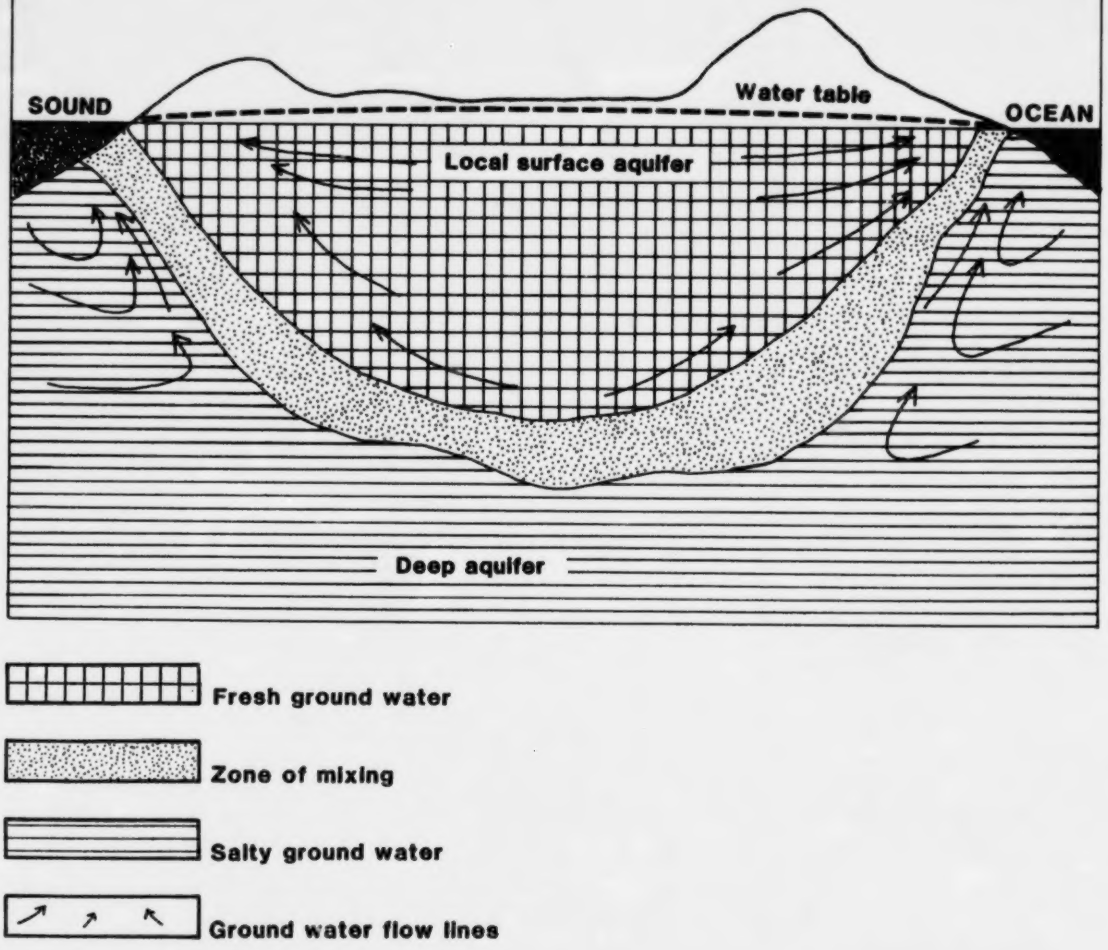

SOUND
Water table
OCEAN
Local surface aquifer
Deep aquifer
Fresh ground water
Zone of mixing
Salty ground water
Ground water flow lines

Figure 2.1.3.b Idealized section of a barrier island of the Outer Banks showing the relationship between ground-water flow and the maintenance of a freshwater lens in the aquifer system.
Source: Claude Terry & Associates, Inc., 1983.

2.1.3 Continued

The depths of the water table and confined aquifers in the upper sandy aquifer vary significantly. In the Dare County Beaches area, for example, the water table aquifer is about 9.15 m (30 ft) below sea level at Mann's Harbor and more than 30.5 m (100 ft) at Kitty Hawk. The depths of the confined beds also vary greatly. Irregular patterns are also observed in the upper sandy aquifer associated with the barrier islands south of Morehead City; however, the limestone aquifer is generally closer to the surface on these islands and is available for water supply.

WATER QUALITY STANDARDS NOT ASSIGNED TO NORTH CAROLINA GROUNDWATERS

The natural quality of barrier island groundwaters varies with location. In some areas the water is drinkable without treatment, while in other areas treatment is required. Problems with pollution of groundwaters are difficult to define since data are limited and quality standards have not been assigned to North Carolina groundwaters. Saltwater intrusion and septic tank malfunctions are the primary sources of groundwater contamination.

The natural quality of the groundwater on the barrier islands is variable. High dissolved solids content or tastes and odors associated with hydrogen sulfide or iron may render waters unpalatable without some treatment. For example, the town of Beaufort provides aeration for removal of hydrogen sulfide while Ocracoke uses reverse osmosis for desalinization. Many public groundwater supplies now in use, however, receive little treatment besides chlorination. Water from individual wells is rarely treated.

Depending upon pumping demand, salt water intrusion may be a problem in some areas. Water from some public wells at the Dare County Beaches, as well as Ocean Isle Beach increases in chloride content during peak seasonal demand and must be closely monitored to prevent loss of the fresh water lens (Mulligan 1981). In areas susceptible to overwash by storm surges or high tides, the water table aquifer is contaminated by saltwater rendering the aquifer useless as a potable water supply. The area around Ocracoke experiences this type of contamination.

The main issue associated with groundwater quality, however, appears to be potential contamination of the water table aquifer by septic tank soil absorption systems or by subsurface discharges from package treatment plants. The principal known threats to the water table aquifer from wastewater discharges are bacterial, viral and nitrate contamination. Other pollutants from these wastewater disposal systems such as organics, and especially chlorinated organics, may also pose a significant threat to groundwater quality for human consumption.

Because the State of North Carolina has not yet assigned groundwater standards, the issue of groundwater pollution is difficult to define. The North Carolina Safe Drinking Water Act describes the requirements for installing the system rather than setting water quality parameters. Furthermore, because groundwater uses are not defined, groundwater quality is legally difficult to protect.

The extent of groundwater pollution associated with subsurface wastewater discharges is difficult to assess because of a lack of reliable data. Operators of wastewater treatment facilities with subsurface discharges permitted by the North Carolina Division of Environmental Management are required to perform self monitoring of groundwaters up gradient and down gradient of the nitrification field or application site; however, generally poor location of test wells and/or deficiencies in sampling techniques have limited the usefulness of this self monitoring data (Shiver 1981). No self monitoring is required for small septic tank systems (less than 11,370 l (3,000 gal)).

Although specific data are limited, the indication from available information is that the widespread use of septic tanks on the barrier islands in areas that have severe site limitations for the use of conventional on-lot systems has most likely caused pollution of the water table aquifer in some areas. The extent of such pollution is unknown, and the effect of soil absorption systems on groundwater quality is highly site dependent. For these reasons, it is not known whether the standard requirements of separation of septic tanks and private wells of at least 15.25 m (50 ft) is adequate to protect individual water supplies in all areas.

In densely developed areas where there is a seasonally or constantly high water table, the continued use of conventional septic tank soil absorption systems threatens the water quality of the groundwater table aquifer. Also, widespread subsurface disposal of package plant effluent may limit the use of the water table aquifer for water supply. The adverse impacts on groundwater quality of such systems should be evaluated on a site-specific or at least a condition-specific basis. Existing and on-going studies that may prove useful in a site-specific EIS include:

- Dare County Health Department, Avon, N.C.. Analysis of test wells to assess coliform transport in the groundwater from septic tank systems. On-going.

- Old Settlers Beach - Surf City. Analysis of test wells to assess coliform and nutrient transport in the groundwater from septic tank systems. (Shiver and Register 1978)

- Investigation of Groundwater Quality Around Septic Tanks in the Coastal Plain. On-going research by C. G. Cogger of North Carolina State University. Preliminary findings indicate that in areas where the absorption trench bottom is normally separated from the water table, excellent treatment is provided (including bacteria removal). Where there is seasonal or constant contact between the water table and absorption trench, treatment is reduced and contaminants move horizontally and vertically in the groundwater.

- Viral Contamination of Groundwater from Septic Tank Effluent. On-going research by Sobsey and Scondera, University of North Carolina. Preliminary findings indicate there is a horizontal movement of viruses in groundwaters down gradient from septic tanks soil absorption fields. The number of wells where viruses are detected decrease with distance from the septic tank. Two factors determine the effectiveness of virual removal in septic tank absorption systems. The greater the distance between water table and trench bottom, the more efficient the removal. Sandy and organic soils are least effective in removal of viruses.

A DIVERSE ASSEMBLAGE OF PLANTS AND ANIMALS EXISTS IN THE ECOSYSTEMS OF COASTAL NORTH CAROLINA

The freshwater, estuarine, marine and terrestrial ecosystems of the study area contain a diversity of flora and fauna. These ecosystems are best described in terms of habitat types and vegetation patterns. This region contains an abundance of wildlife.

The barrier island area of North Carolina contains a wide variety of aquatic and terrestrial communities. Each of these ecosystems is represented by a rich diversity of plants and animals including a number of species that are protected by state or federal regulations. The freshwater system is represented by small ponds and marshes that are widely distributed on most of these islands. The estuarine ecosystem can best be described by dividing it into component subhabitats. The six major subsystems of the estuarine bays and sounds are discussed in the following sections. These include sand and mud sediment, saltmarsh, seagrass beds, oyster reefs, open water plankton and reduced salinity (oligohaline) systems. While there has been some degradation to these subsystems, much of the area still has a rich fauna.

The marine ecosystem can be divided into four major components. These include high energy beaches and sediment areas, open-water plankton, natural and artificial reefs. The marine mammals and reptiles are not an actual component subsystem but are discussed separately because they are wide-ranging species. The open water areas are dominated by pelagic fishes and plankton, and the sediment areas and reefs are dominated by burrowing and attached invertebrates and associated fishes. This ecosystem supports a number of species of commercial importance.

The terrestrial ecosystem is divided into seven communities. These include dunefields, grassflats, shrub thickets, maritime forests, swamps, freshwater marshes and saltmarshes. Terrestrial wildlife distributions are largely associated with these vegetation patterns.

The following sections discuss in detail each of the four major ecosystems.

BARRIER ISLAND FRESHWATER SYSTEMS ARE RESTRICTED TO SMALL PONDS AND MARSHES

The freshwater systems on the barrier islands are generally restricted to small ponds, marshes and swamps. Direct information regarding these freshwater communities in the study area is incomplete. However, most of these areas can be found in undisturbed regions on the islands and therefore are likely to be of high quality.

The freshwaters of the barrier islands of North Carolina are generally restricted to small to medium sized ponds, marshes and swamps. These standing water systems are supplied by the ground water table and rainwater. No running water streams are found on the barrier islands except during times of heavy rains when the various freshwater ponds and marshes may be connected. In general, some freshwater ponds and marshes are found on all the barrier islands. Section 2.2.4 covers the major plants, birds, mammals, amphibians and reptiles associated with the freshwater communities on these islands.

Water quality and the abundance of habitat types will determine the numbers and types of aquatic life found in the freshwater ponds and marshes of these barrier islands. The intrusion of salt water will also affect these freshwater communities. While little direct research has been conducted regarding freshwater systems on the barrier islands, most of these areas are probably in good condition because they are usually located in undisturbed areas. The most direct effect on these systems comes from runoff from adjacent developed areas and feral grazing animal populations. In areas where water quality is high, the fauna can be expected to include numerous insect groups (e.g., mayflies, dragonflies, midges, deer flies, beetles) and oligochaetes (worms) as well as many species of reptiles and amphibians. These freshwater systems are based on both plankton and detritus from decaying organic material. The dominant fish species are mosquito fish, minnows, killifishes, sunfishes, (U.S. Dept. of Interior 1978, 1980).

Much of the work regarding barrier island freshwaters has been conducted outside the EIS study area, and therefore, more exact descriptions of this habitat on these islands cannot be presented at this time. The ponds are basically a plankton based food chain and the fringes of these ponds are dominated by emergent vegetation. The swamps and marshes are dominated by submerged and emergent vegetation with numerous associated fish and invertebrate species.

Section 2.2.4.7 discusses freshwater marshes from a terrestrial viewpoint. Freshwater swamps are discussed in Section 2.2.4.6.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.2 Estuarine Ecology

THE ESTUARINE ZONE CONTAINS AN ABUNDANCE OF HABITAT AND EXTENSIVE FLORAL AND FAUNAL COMPONENTS

The estuarine subhabitats include sand and mud sediments, saltmarsh, seagrass beds, oyster reefs, open-water plankton systems and oligohaline systems. All of these habitats play an important role in the estuarine structure and function. The estuarine zone contains numerous species of both finfish and shellfish.

The types of estuarine communities are functions of water quality and the general abundance of habitat types. The estuarine zone of North Carolina does show natural variations in physical and chemical parameters, and these estuaries are in an undisturbed state with some exceptions (See Section 2.1.2 for estuarine water quality). Production of finfish and shellfish from North Carolina can be found in Section 3.5.3.

Estuaries are complex ecosystems and are extremely difficult to characterize. These areas are naturally enriched from the transport of organics from adjacent terrestrial areas, natural nutrient recycling in component estuarine subsystems, and transport of nutrient material from the freshwater rivers. These ecosystems are extremely important to the marine shellfish and finfish because they provide not only an abundance of food, but also a breeding and nursery ground for many of the commercially important species.

For the purpose of this report, the estuarine region behind the barrier islands can be divided into six separate subhabitats: sand and mud sediment, saltmarsh, seagrass beds, oyster reefs, open-water plankton systems and oligohaline systems. The first five subhabitats will be discussed as they pertain to the medium salinity (5-18 parts per thousand (ppt)) estuary. This is the dominant salinity for most of coastal North Carolina. The oligohaline systems (less than 5 ppt) is separated from these other sections because salinities in this range cause a shift in the species level in each of the habitat areas.

All of these six subhabitats play an important role in the overall maintenance of the estuarine systems of North Carolina. More complete descriptions for each of these subhabitats can be found in the following sections. Figure 2.2.2 shows each of the major estuarine subhabitats and the dominant species in each of these areas. For a more complete species list of fishes and invertebrates for North Carolina, the reader is directed to the following references: Peterson and Peterson (1979), U.S. Dept. of Interior (1978, 1980), Zingmark (1978), Odum et al. (1974) and Gosner (1971).

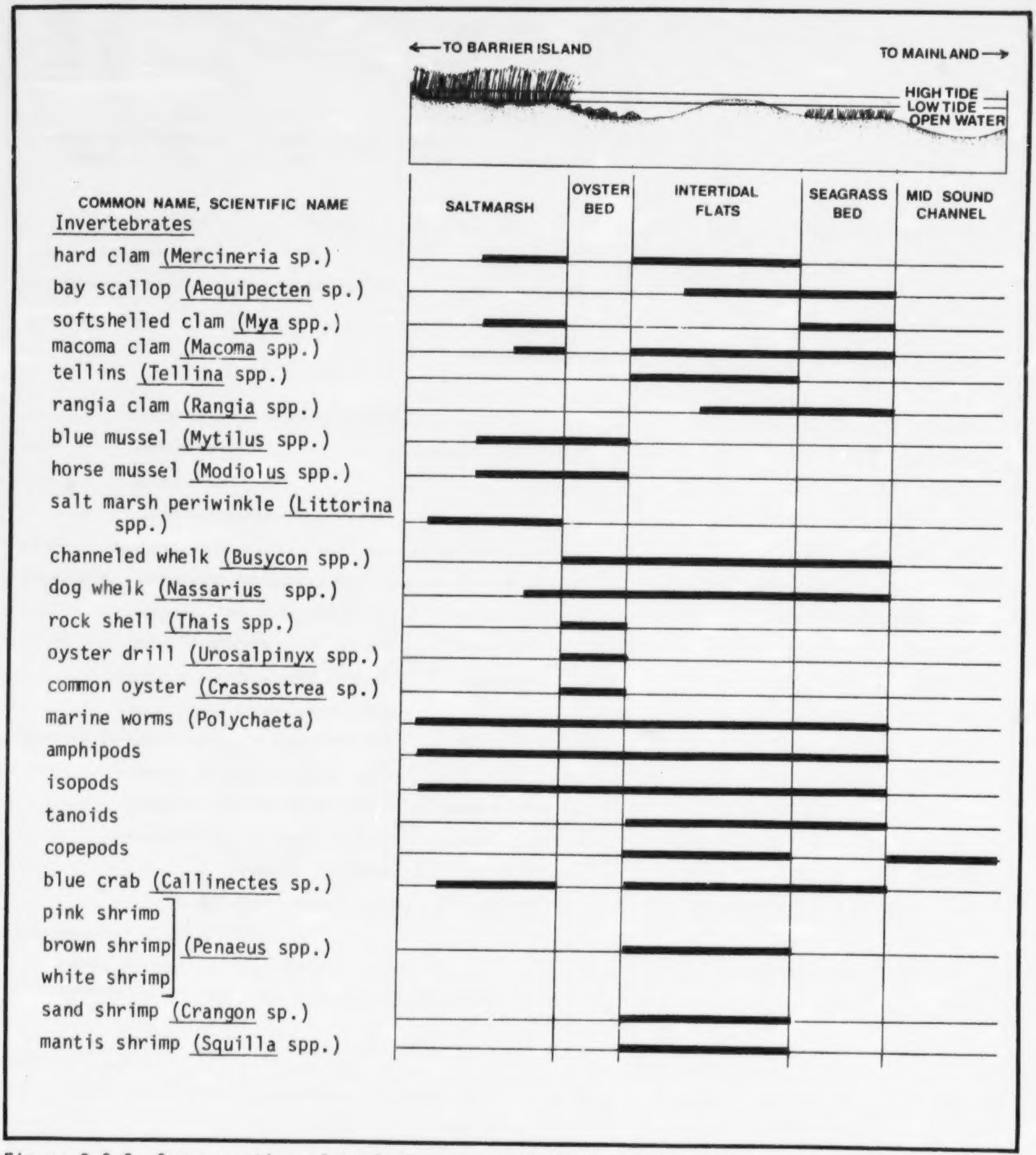


Figure 2.2.2 Cross section of typical estuary of North Carolina showing the major estuarine subhabitats and dominant species for each zone (Based on Odum et al. 1974).

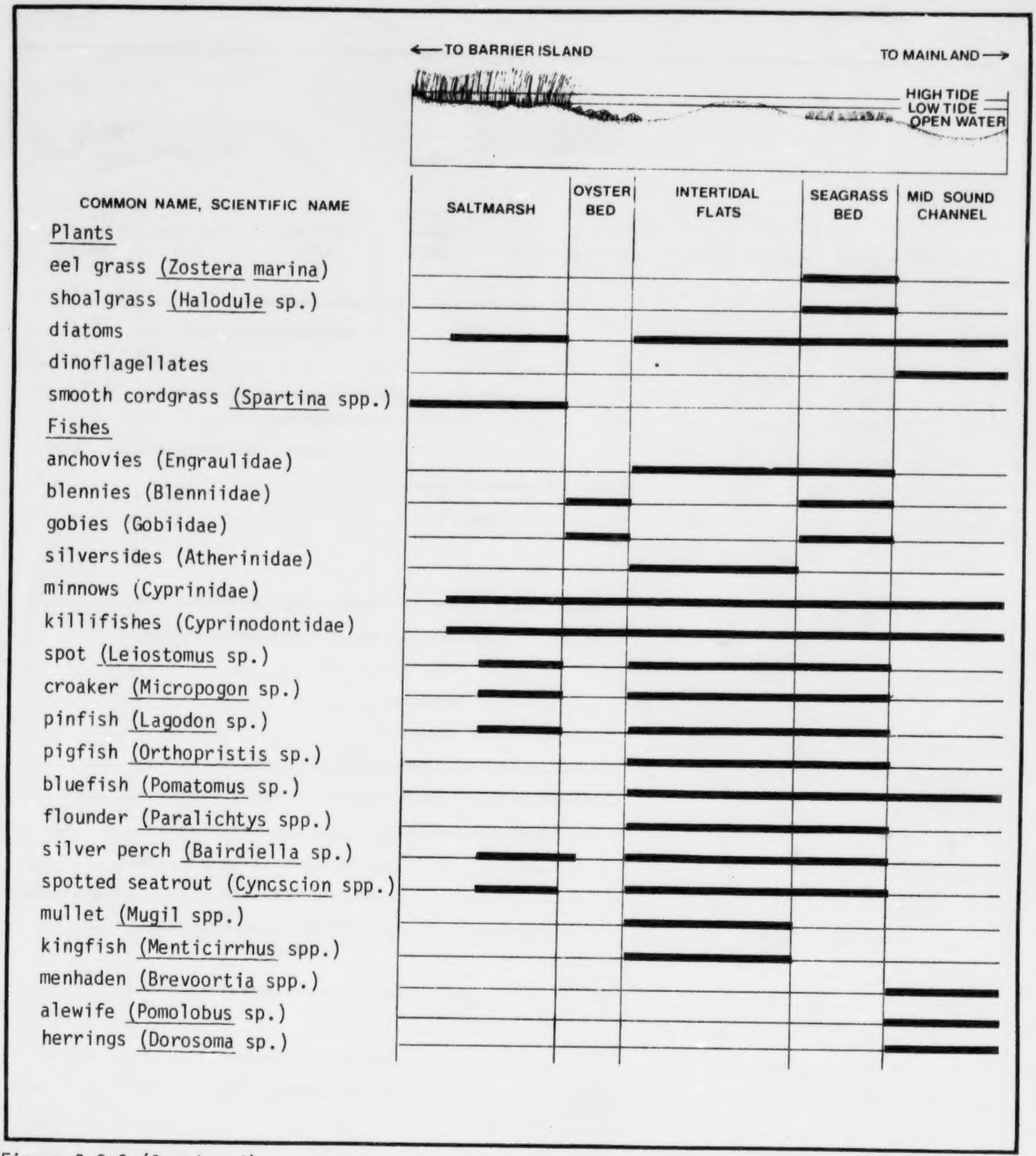


Figure 2.2.2 (Continued)

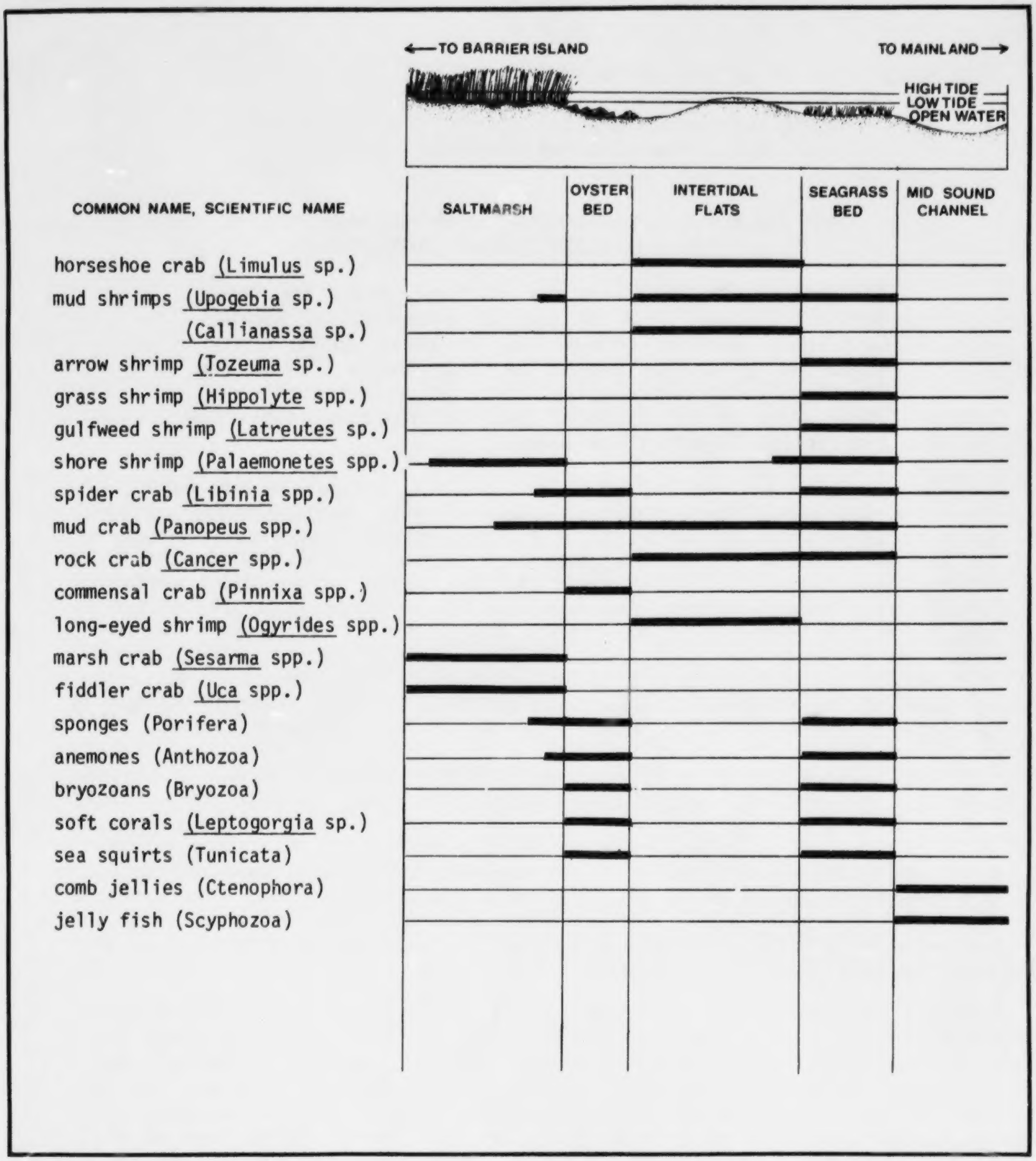


Figure 2.2.2 (Continued)

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.2 Estuarine Ecology
2.2.2.1 Sand and Mud Sediments

SAND AND MUD SEDIMENT AREAS ARE THE DOMINANT HABITAT TYPES IN COASTAL NORTH CAROLINA

The unvegetated sand and mud sediment zones are the dominant habitat type in coastal estuaries of North Carolina. Benthic communities in these zones are supported by primary production from benthic diatoms and dinoflagellates and detrital material transported from other areas of the estuary. Numerous important shellfish and finfish inhabit these areas.

The open sand and mud sediment areas are the dominant benthic habitats in the estuarine zone. These habitats represent both intertidal and subtidal sediment areas where no submerged or rooted vegetation exists. The type of sediment will be one of the most important factors that determines the kinds of organisms that will inhabit these sediment zones. The muddier sediments occur in the slower current areas where silts can accumulate. The coarse and fine sands are located near the inlets, behind the barrier islands and in the areas of overwash from these islands (Peterson and Peterson 1979). The unvegetated sediment zones are dominated by more sand than other estuarine areas of the south Atlantic coast. In general, the open sediment habitat is dominated by numerous burrowing infaunal and surface epifaunal species.

Figure 2.2.2 shows the relationships of the component estuarine subsystems and the dominant species that inhabit this area. Because the physical nature of this habitat precludes the significant formation of plant production, the community is dependent on the transportation of organic material from adjacent areas of the estuary. However, there is primary production from the many species of benthic diatoms and dinoflagellates. This source of food plus the additional detrital material from other parts of these estuaries make these sediments areas quite productive in terms of fish and invertebrates (Odum et al. 1974).

The dominant invertebrate species in the sediment areas (intertidal flats, Fig. 2.2.2) of the North Carolina coastal zone are the mollusks (hard clams, bay scallops, tellins, odostomes, whelks, conchs, dog whelks, mud whelks), polychaetes, amphipods, isopods, mantis shrimps, long-eyed shrimps, sand shrimps, brown shrimps, horseshoe crabs, blue crabs, mud shrimps, hermit crabs, mud crabs and rock crabs (Peterson and Peterson 1979, Odum et al. 1974). In general, these sediment areas contain numerous species and are in a healthy condition along the barrier island chain (Peterson and Peterson 1979). Many of these species are of commercial importance to the North Carolina area.

A number of fish species can be found in the waters which periodically inundate these sand and mud sediment zones: spot, weakfish, flounders, pinfish, croaker, anchovies, striped bass, black sea bass, mullets, silver perch, pigfish and kingfish (Peterson and Peterson 1979). Many are important local sport and commercial fishes.

2.2.2.1 Continued

In addition, many birds feed on these intertidal flats (see Section 2.2.4 for discussion of terrestrial wildlife on barrier islands). The diversity and number of species in North Carolina coastal regions shows that these estuaries are in a healthy state. Rich harvests of shellfish and finfish are expected to continue from these waters (Peterson and Peterson 1979). However, impacts from mainland activities may cause future problems.

2.2.2.2 Saltmarsh

SALTMARSH COMMUNITIES COVER VAST AREAS OF NORTH CAROLINA ESTUARINE ZONE

The saltmarsh community is a highly productive area in estuarine systems. Saltmarshes provide abundant decaying detrital material to the adjacent benthic communities. The saltmarsh is also a nursery area for many species of juvenile fishes, shrimps and crabs.

The saltmarsh regions often cover large areas just behind the barrier islands (see Section 2.2.4 for location and distribution of saltmarshes). The dominant marsh plants in this area are smooth cordgrass (*Spartina alterniflora*) and black needlerush (*Juncus roemerianus*). Section 2.2.4 covers the other major plant and animal species associated with the saltmarshes for this area.

Figure 2.2.2.2 shows a typical view of the North Carolina saltmarsh system. The saltmarsh not only serves as a nursery and breeding grounds for numerous species but also provides the adjacent estuarine waters and benthic communities with a detrital food source (Odum et al. 1974). This detrital material is colonized by bacterial growth which is the source of food for numerous invertebrate species. The continued maintenance of saltmarshes is essential to the overall health of the entire estuarine region. These areas also provide habitat and nesting areas for many waterfowl (see Section 2.2.4).

Saltmarshes are intertidal beds of rooted vegetation extending from somewhat above low tide level to levels inundated only by extreme high tides on the sound side of barrier islands. These marsh areas often have small creeks cutting through them. These creeks aid in flushing marsh areas of waste products and detrital material.

Figure 2.2.2 shows the relationship of the saltmarsh to other subsystems in the coastal region as well as the dominant floral and faunal components of this subsystem. The saltmarsh community is dominated by fiddler crabs, marsh crabs, blue crabs, commercial shrimps, saltmarsh periwinkle, horse mussels, hard clams, amphipods, isopods and numerous species of polychaetes (Odum et al. 1974). Estuarine fishes found in the tidal creeks and marshes include spot, croaker, silver perch, blue fish, anchovies, killifishes and silversides. The shellfish of commercial importance include hard clam, blue crab, and shrimp (U.S. Dept. of Interior 1978, 1980).

Section 2.2.4.8 further discusses saltmarshes. Figures 2.2.4-c-e list the plants and animals associated with saltmarshes while Appendix 2.2.4 provides a checklist for birds.

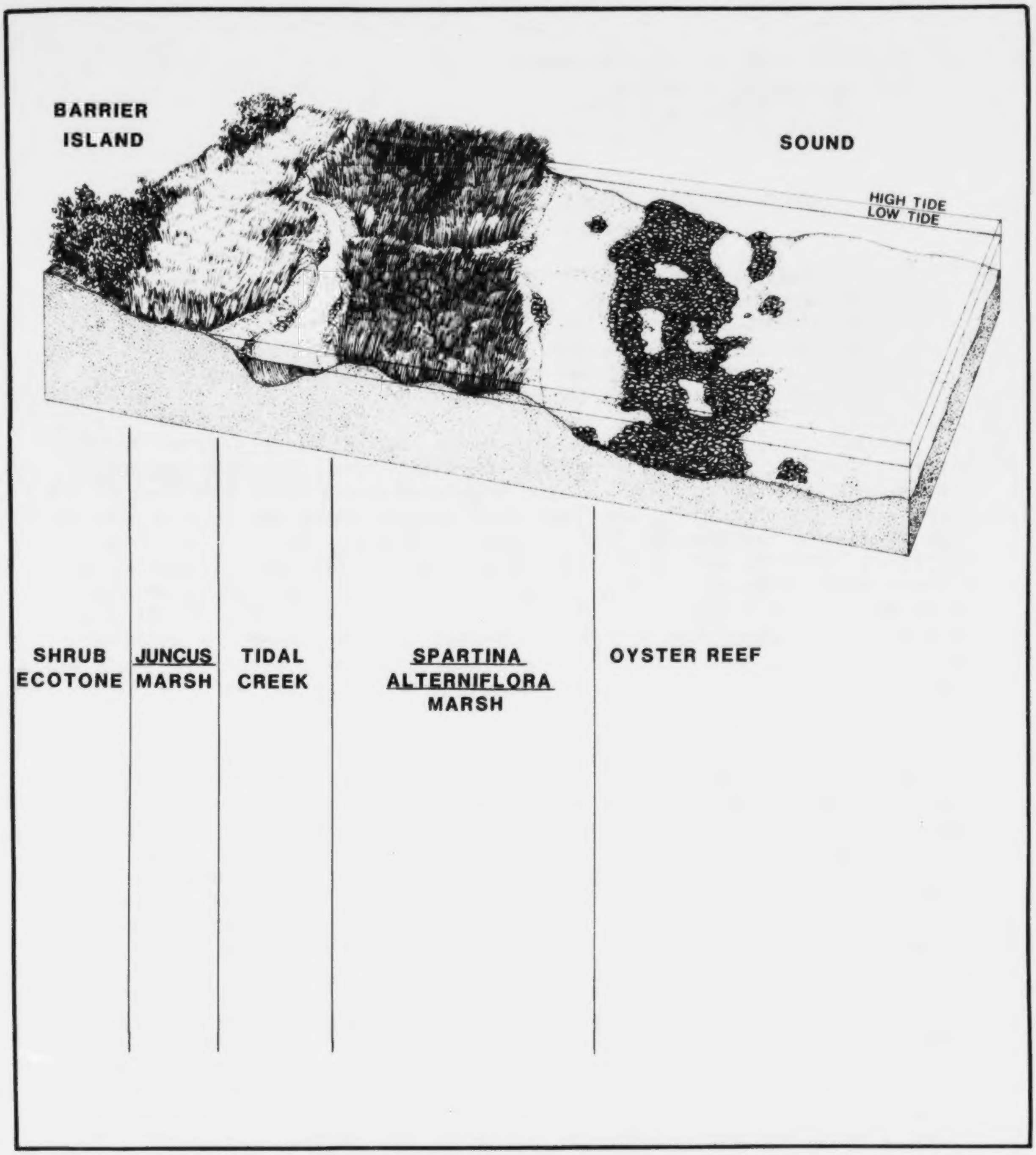

BARRIER ISLAND
SOUND
HIGH TIDE
LOW TIDE
SHRUB ECOTONE
JUNCUS MARSH
TIDAL CREEK
SPARTINA ALTERNIFLORA MARSH
OYSTER REEF

Figure 2.2.2.2 Typical View of North Carolina Saltmarsh and Oyster Reef Association.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.2 Estuarine Ecology
2.2.2.3 Seagrass Beds

NORTH CAROLINA SEAGRASS BEDS SUPPORT MANY FINFISH AND SHELLFISH SPECIES

The seagrass bed community is represented by numerous beds of varying sizes. This community supports a large number of finfish and shellfish. This habitat serves as an attachment site for algae, provides food to surrounding benthic and water column areas, serves as a nursery ground, and stabilizes the sediment.

Typically, two seagrass species grow in the estuarine area of North Carolina: eel grass (Zostera marina) and shoal grass (Halodule beaudettei) (Phillips 1974, Roberts 1974). These seagrasses are a major component of the estuary and are especially important as a nursery ground and feeding area for many species of commercial finfish (spot, flounder, pinfish, etc.) and shellfish (bay scallops, soft clam, blue crab, shrimp, etc.) (Adams 1976a, Kikuchi 1966, Robertson 1977). These beds also provide protection from predators for many juvenile finfish and shellfish, provide a direct and indirect food source for estuarine species, provide oxygen to adjacent estuarine waters, provide substrate and habitat for many species of flora and fauna, and act as a sediment trap to stabilize bottom sediments (Phillips 1974).

The normal patterns of distribution for seagrasses is subject to seasonal variation (Dillon 1966, 1971). Eel grass forms extensive beds throughout Pamlico, Core and Bogue Sounds during the spring and summer months and is then replaced by shoal grass during the winter months (Dillon 1966, 1971). The distribution of eel grass on the North Caroina coast is documented as far south as Beaufort (den Hartog 1970), but probably exists somewhat further south. (Dillon 1966, 1971). Because of the seasonal variation and lack of published information on actual locations of seagrass beds, detailed mapping of North Carolina seagrass beds cannot be produced at this time.

Figure 2.2.2 shows the dominant floral and faunal components of the North Carolina seagrass community. These seagrass meadows are extremely productive areas (Thayer et al. 1975, McRoy and McMillan 1977) in terms of both plant and animal components (Thayer et al. 1975, Orth 1977, Adams 1976a). While the seagrass itself provides a direct source of food to some species of estuarine fish and invertebrates, the attached algae on the seagrass is probably more important as the basic food in the seagrass ecosystem. This attached algae is grazed upon by numerous small invertebrate groups which are in turn the food source of many important fish species.

The dominant fish and invertebrate species in the seagrass meadows of North Carolina are the following:

Invertebrates: anemones, bryozoans, hydroids, isopods, amphipods, estuarine worms, many species of snails and clams, blue mud shrimp, arrow shrimp, grass shrimp, shore shrimp, blue crab, and pink, white, and brown shrimp.

Fishes: pinfish, spot, bay anchovy, Atlantic silverside, silver perch, pigfish, blennies, gobies, bluefish and flounder (Adams 1976a, 1976b, 1976c, Orth and Heck 1980a, 1980b).

Many of these species are only seasonal inhabitants of the seagrass community, particularly the fish species, because many of these species use this subhabitat as a nursery area. In addition, numerous bait fish, anchovies, killifishes, silversides, and larger juvenile finfish, drums, porgies, flounders, grunts and mullets forage through these meadows for food or use them for protection from predators. Some of the commercially important shellfish that use the seagrass beds in North Carolina include the bay scallop, soft shell clam, hard clam, and the pink, white and brown shrimps (U.S. Dept. Interior 1978, 1980).

Some degradation of seagrass beds has occurred as a result of clamming activities.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.2 Ecological Inventory

2.2.2 Estuarine Ecology

2.2.2.4 Oyster Reefs

OYSTER REEFS SUPPORT A LARGE NUMBER OF FISH AND INVERTEBRATE SPECIES

Oyster reefs present a hard substrate for the attachment of numerous species of sessile invertebrates. These areas have a high diversity of fish and invertebrates. Oyster reefs are widely distributed throughout the coastal region of North Carolina.

Oyster reefs are based upon the successive generations of the common oyster (*Crassostrea virginica*). These reefs serve as a hard substrate for an abundance of estuarine life (Odum et al. 1974). As noted in Section 2.2.2.2, oyster reefs are often found in close proximity to saltmarsh systems and are often found extending into the tidal creeks (see Figure 2.2.2.2.). They may also be found interspersed with the submerged seagrass community, since stable sediment is needed in order for oysters to successfully settle and form a reef community.

Oysters are filter feeders and thus dependent on the transport of food materials from other parts of the estuary (seagrass beds, saltmarsh, or water column) for their survival (Odum et al. 1974). Because of the hard substrate, numerous sessile organisms including sponges, anemones, bryozoans, soft corals, and tunicates are able to form an important part of these communities. Figure 2.2.2 shows the common dominant species associated with the oyster reef community in coastal North Carolina. Section 3.5.2 discusses the distribution of oyster reefs in the estuarine region of North Carolina. Beside the oyster, other invertebrates such as the stone and blue crab have commercial value for this area.

The dominant fishes from oyster reefs include gobies, blennies and pinfish. Because of these numerous bait fishes, many of the larger fish species (bluefish, croaker, spot, seatrout, mullet and striped bass) congregate around these reefs as they forage for food.

Numerous factors can affect the survival of oyster reefs. Perhaps the greatest hazard to oyster production is dredge and fill oprations which cover oyster reefs with silt. Currently, oyster reefs are still widely distributed in the state (see Section 3.5.2), but degradation in these oyster reef zones has occurred due to lower salinities and pollution.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.2 Estuarine Ecology
2.2.2.5 Open Water Plankton Systems

OPEN WATER ZONE LINKS ESTUARINE HABITATS

The open water system represents all the water over the various benthic habitats and links the entire estuary through the tides and currents. This area provides for transport of food and the dispersion of benthic larval forms as well as a flushing mechanism for the whole estuary.

The open water plankton zone includes all the water column areas above all the previously mentioned benthic zones. The water column zone is a phytoplankton-zooplankton based system, and at certain times of the year the concentration of plankton can be extremely high. The open water systems in North Carolina can be termed a medium salinity plankton based ecosystem (Odum et al. 1974). The basis of this water column's food chain comes from the microscopic plants (phytoplankton) which are consumed by small planktonic invertebrates (zooplankton) (Bellis 1974). These two groups are then the food source of many types of fish, such as Atlantic menhaden (see Figure 2.2.2.5 for basic food chain for North Carolina estuaries).

The open water zone is important to the maintenance of the entire estuary because, together with the tides and currents, they serve as the transport vehicle for the removal of waste products and provide food material to other parts of the estuary (saltmarshes, seagrass beds, benthic sediments, etc.) (Bellis 1974). The water column also is the main means by which benthic invertebrates disperse to inhabit other parts of the estuarine bays. Since many of these benthic organisms have planktonic larvae, the tides and currents transport these organisms throughout the estuary, ensuring colonization of all likely substrates. In addition, the organisms produce organic food material which settles to the bottom and can then be used as food by many fish and invertebrates.

Phytoplankton consists of diatoms and dinoflagellates. In North Carolina, the dominant estuarine species are the diatoms *Skeletonema costatum* and *Rhizosolenia fragilissima* (Bellis 1974). Zooplankton consists of crustacean groups and larvae of many benthic invertebrates. The plankton fauna will also include the larvae and juveniles of many fish species. In North Carolina, the dominant zooplankton is the copepod crustacean *Acartia tonsa* in spring and summer and *Acartia clausi* during fall and winter (Bellis 1974, Peterson and Peterson 1979). In addition to the numerous small bait fishes (minnows, anchovies, silversides etc.) and fish larvae, the dominant plankton feeding fishes of this system are the alewife, menhaden, and thread herring (Odum et al. 1974).

While most of the commercially important fish species (croaker, spot, silver perch, sea trout, flounder, etc.) are not found exclusively in this zone, they do make use of it to travel through the estuary to nursery and breeding grounds as well as to forage for small fish and invertebrates.

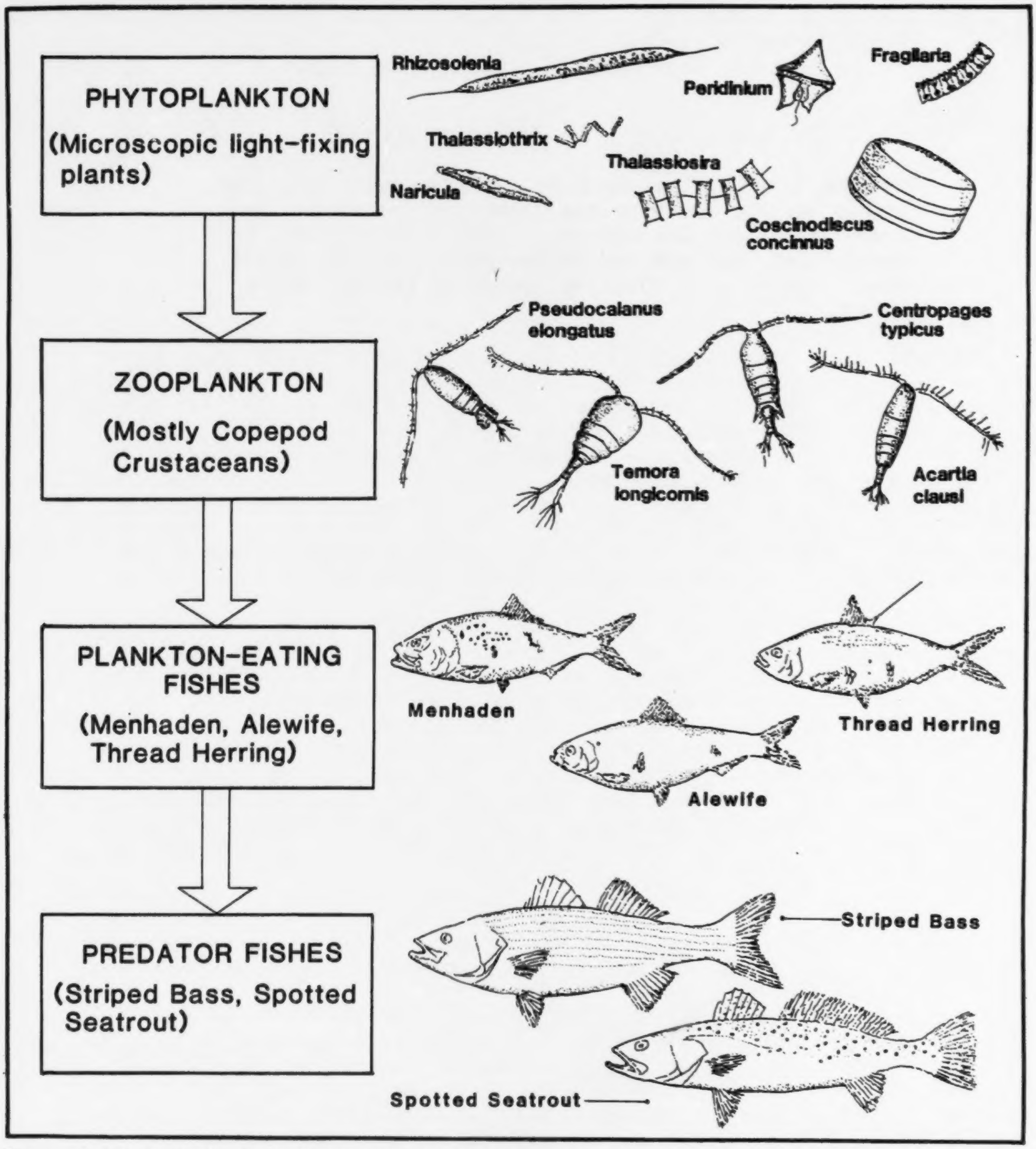

PHYTOPLANKTON
(Microscopic light-fixing plants)
Rhizosolenia
Peridinium
Fragilaria
Thalassiothrix
Thalassiosira
Naricula
Coscinodiscus concinnus
ZOOPLANKTON
(Mostly Copepod Crustaceans)
Pseudocalanus elongatus
Centropages typicus
Temora longicornis
Acartia clausi
PLANKTON-EATING FISHES
(Menhaden, Alewife, Thread Herring)
Menhaden
Thread Herring
Alewife
PREDATOR FISHES
(Striped Bass, Spotted Seatrout)
Striped Bass
Spotted Seatrout

Figure 2.2.2.5 Basic Food Chain of North Carolina Estuarine Plankton Systems (from Odum et al. 1974).

2.2.2.6 Oligohaline Systems

OLIGOHALINE SYSTEMS INCLUDE CURRITUCK SOUND AND ALBEMARLE SOUND IN NORTH CAROLINA

A number of species common to the higher salinity estuarine areas are found in the low salinity zones. Due to the lack of significant currents and increased stress, low salinity zones have reduced species diversity. However, a number of commercially important species are found in this area.

Low salinity (oligohaline) systems have a salinity range between 0.0 to 5.0 parts per thousand. These oligohaline systems can be found in all the river mouths on the mainland side but mainly in Currituck Sound down to Roanoke Island behind the barrier islands. Because this is a harsh environment, the number of species is usually lower than that of the higher salinity parts of the estuary.

In the seagrass beds of oligohaline zones, the normal plants are widgeon grass (Ruppia maritima) and tape grass (Vallisneria americana). The dominant invertebrates are the rangia clam, macoma clam, amphipods, isopods, shore shrimps and blue crabs. The fish of this system are the spot, croaker, seatrout, and striped bass, catfish, herrings and shads. The open sediment areas have many of the same invertebrates as the grass flats. These same fish species can be found throughout the tidal creeks and the subtidal and intertidal sediment areas, with the addition of juvenile flounders.

The saltmarsh system of this low salinity regime consists of the black needlerush (Juncus roemerianus) along with the following invertebrates: rangia clams, blue crabs, fiddler crabs, shore shrimps, marsh periwinkles and marsh crabs. The open water plankton community is much the same as the medium salinity parts of the estuaries, with the exception that the number of species is reduced. The same two dominants (phytoplankton and zooplankton, see Section 2.2.2.5) of the plankton community can also be found in this system. The dominant fish of this system include: alewife, shads, menhaden, silversides, white perch, spot, croaker, herrings, flounders, striped bass and killifishes (Odum et al. 1974).

Figure 2.2.2.6 shows a simplified view of the food chain of the oligohaline systems of North Carolina. This does not include all species, but gives the general view of the food chain dynamics of these systems. Organic detritus and phytoplankton form the basis of the food chain that ends in the large predator fish (striped bass, spot, flounder, etc.) (Odum et al. 1974).

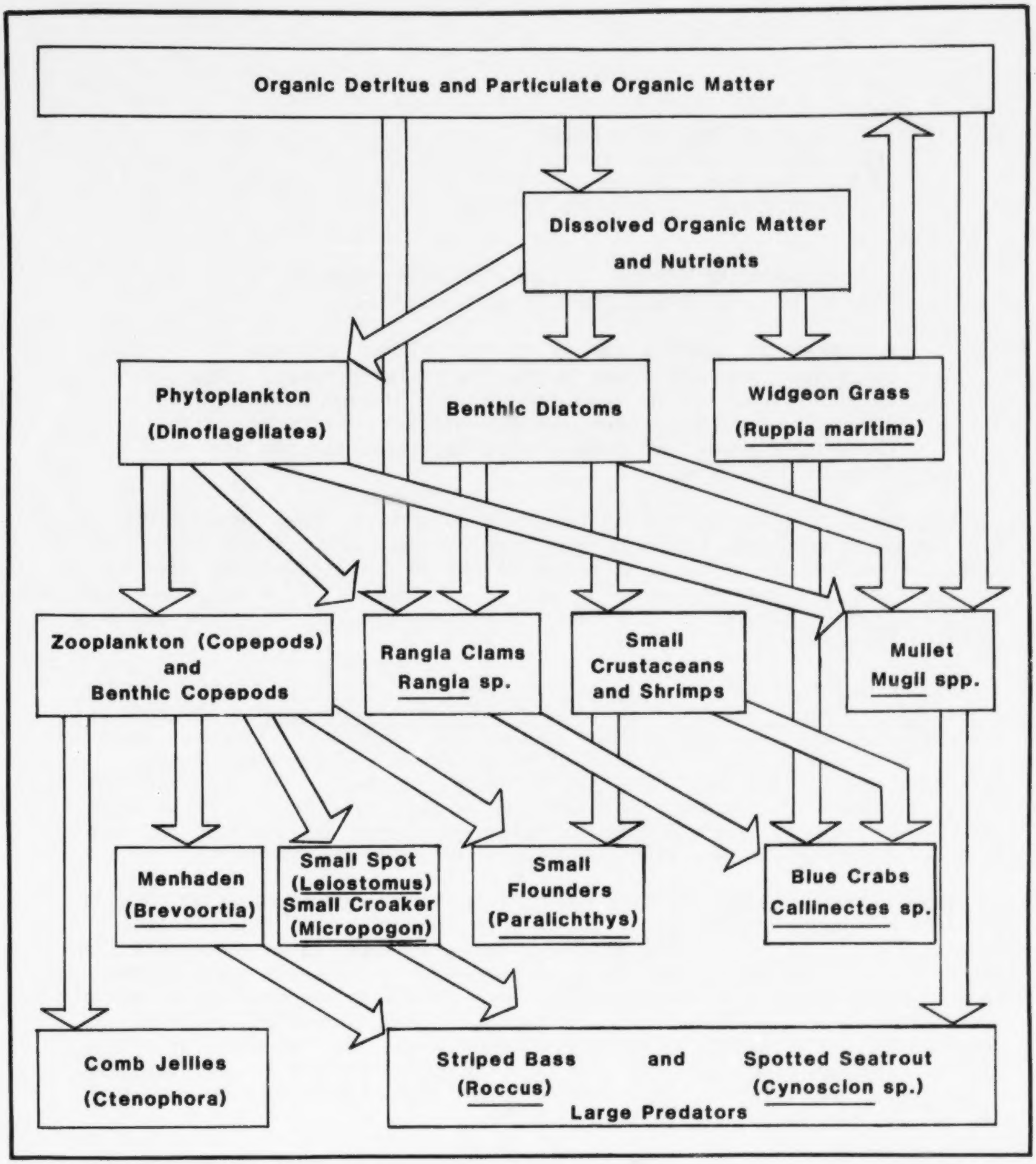

Organic Detritus and Particulate Organic Matter
Dissolved Organic Matter and Nutrients
Phytoplankton (Dinoflagellates)
Benthic Diatoms
Widgeon Grass (Ruppia maritima)
Zooplankton (Copepods) and Benthic Copepods
Rangia Clams Rangia sp.
Small Crustaceans and Shrimps
Mullet Mugil spp.
Menhaden (Brevoortia)
Small Spot (Leiostomus) Small Croaker (Micropogon)
Small Flounders (Paralichthys)
Blue Crabs Callinectes sp.
Comb Jellies (Ctenophora)
Striped Bass (Roccus) and Spotted Seatrout (Cynoscion sp.)
Large Predators

Figure 2.2.2.6 Simplified view of the food chain of all oligohaline (i.e. low salinity) systems of North Carolina (from Odum et al. 1974). Arrows indicate the normal flow of food material.

MARINE ENVIRONMENT SUPPORTS SIZEABLE SHELLFISH AND FINFISH COMMUNITIES

The marine systems of North Carolina are located along the continental shelf. These systems include high energy beaches and sediment areas, open water plankton systems and reef communities. The marine communities support numerous fish and invertebrates, many of commercial importance to the North Carolina area.

The type of marine communities that can be expected offshore along the barrier islands are dependent mostly on sediment type, season and water quality. In general, offshore marine systems are more diverse, in terms of invertebrate and fish species, than the estuarine systems. However, while species diversity is high, the relative abundance (number/m^2) is lower than that of estuarine systems. This general diversity/abundance relationship is true for the soft sediment offshore areas, but where reef communities occur, diversity, abundance, and production are all high (Odum et al. 1974, U.S. Dept. of Interior 1978, 1980).

The marine systems extend offshore to the Gulf stream and are located within the Atlantic continental shelf. These systems contain elements of tropical and temperate faunal organisms. The offshore marine systems consist of the high energy beaches and associated intertidal and subtidal sandy benthos as well as nearshore plankton system and hard bottom communities (live bottoms, snapper banks, reefs). Each of these will have a characteristic fauna, and together they are responsible for the rich shellfish and finfish fauna found along this coast (U.S. Dept. of Interior 1978, 1980).

For the purpose of this report, the marine environment is divided into four parts: high energy beaches and sediment areas, open-water plankton systems, natural and artificial reefs, and marine mammals and reptiles. The first three sections deal with the ecological principles of each of these marine subsystems as well as major species characteristics and current conditions. The marine mammals and reptile section is considered separately since these animals do not specifically use any one nearshore habitat.

The following sections will attempt to show the structural and functional aspects of each of these marine systems as well as the major species associations for each of these systems. Figure 2.2.3 shows each major marine subsystem with the major species associations (see Sections 2.2.3.1-2.2.3.3 for more ecological information). The marine systems of North Carolina support large numbers of finfish and shellfish, which can be attributed to the high water quality of this region.

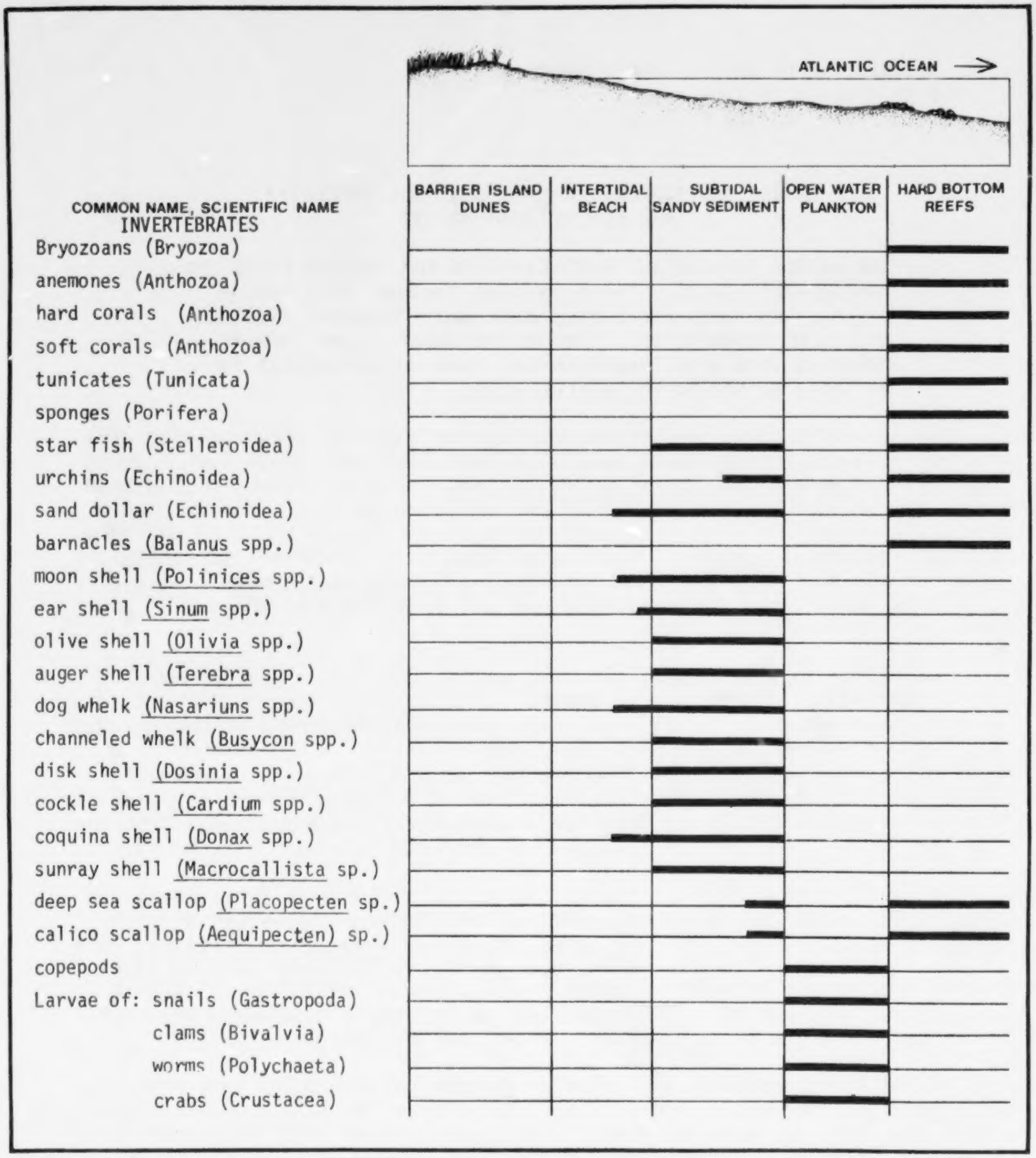


Figure 2.2.3 Cross section of typical marine systems extending from the beaches of North Carolina barrier islands and showing the major species for each zone.

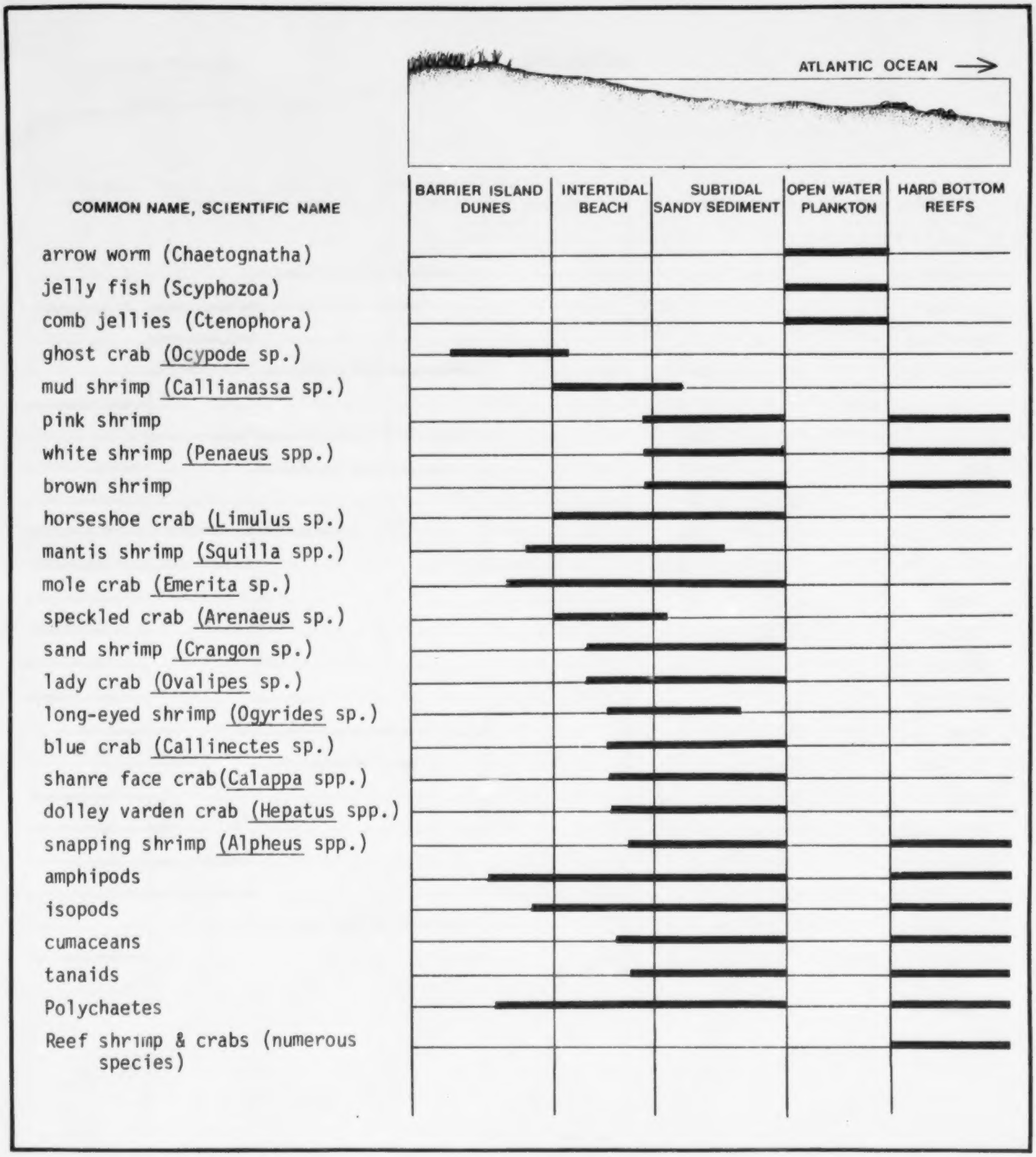


Figure 2.2.3 (Continued)

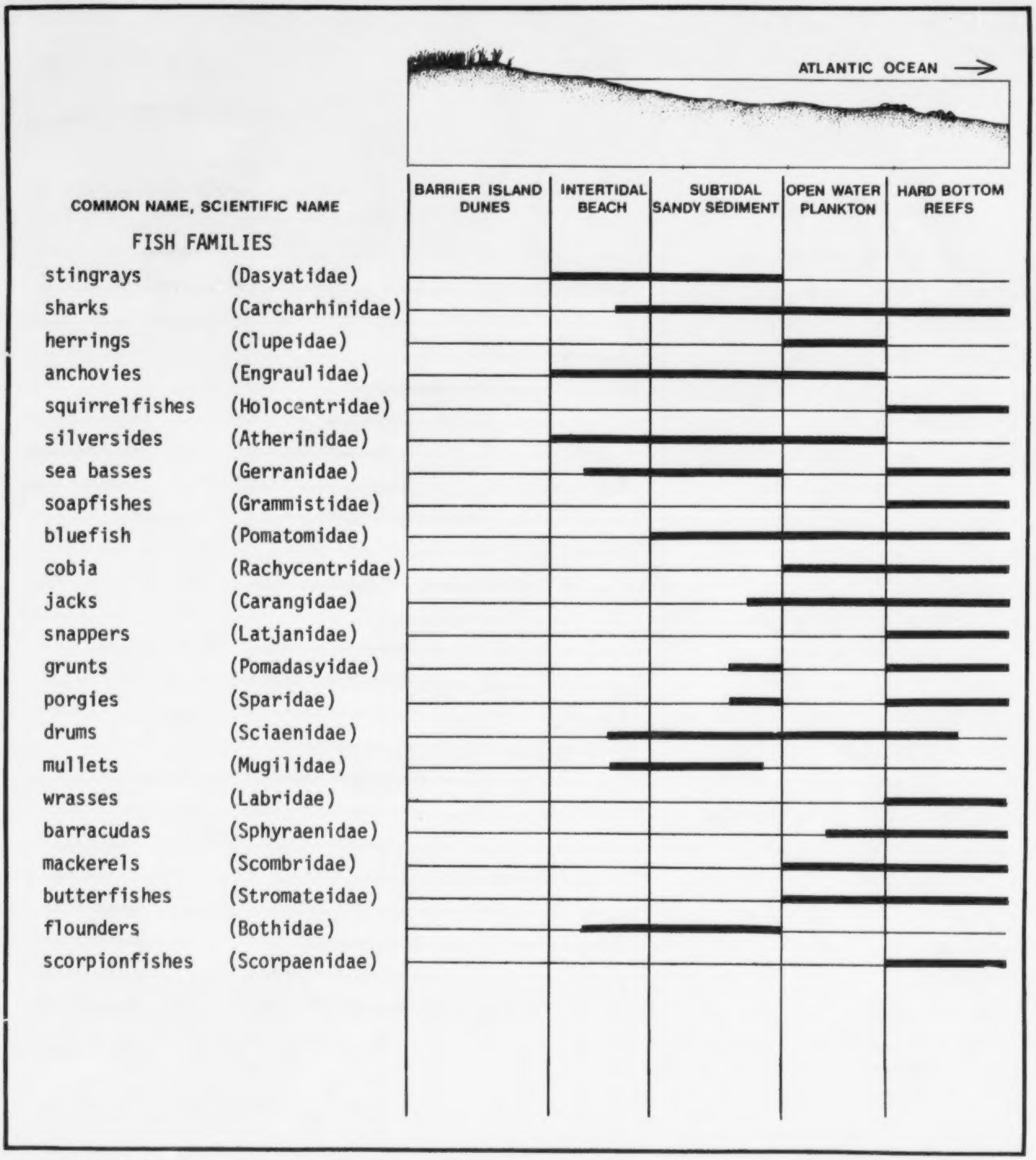


Figure 2.2.3 (Continued)

2.2.3.1 High Energy Beaches and Sediment Areas

HIGH ENERGY BEACHES AND SANDY SEDIMENT AREAS ARE THE DOMINANT NEARSHORE BENTHIC HABITATS

The high energy beaches and soft sediment areas are the major habitat areas in the nearshore marine region of North Carolina. These areas are dominated by numerous species of clams, snails, crabs, and shrimps. The major fish are drums, porgies, grunts, anchovies, flounders, mullets, sharks and stingrays. Many of the shellfish and finfish are important to local interests.

The high energy beach and open sediment areas are the dominant features of the nearshore marine region. This habitat represents both intertidal and subtidal open sediment areas. These areas are characterized by highly unstable sands which preclude the attachment of sessile organisms. The currents and tides cause the continuous movement of sediment along the coast. Because these benthic habitats are constantly shifting, most of the organisms are burrowing types. Just as with the open sediment areas in the estuaries (Section 2.2.2.1), the open marine beaches and sediment areas are heterotrophic. There is some primary production from benthic diatoms, but additional food sources are needed for these areas to support the biota (Odum et al. 1974). These zones are supplied with additional food sources from offshore communities as well as flushing from the estuaries. These factors make these regions fairly productive and of importance to local finfish and shellfish interests.

The open sediment areas can be separated into two zones. The high energy beaches are usually intertidal sandflats and are exposed at low tide. The subtidal sand-mud habitat exists from the barrier islands out to the continental shelf. The main difference between these two zones is that wave energy is greater along the beaches and intertidal sandbars than in subtidal sand-mud areas. The intertidal habitat is dominated by more highly specialized burrowing forms. In the offshore sediment zone, the soft sediments are often intermixed with patches of rock outcroppings which support reef communities (see Section 2.2.3.3). The offshore sediment area contains burrowing and epifaunal species.

Figure 2.2.3 shows the relationships of component marine subsystems and the dominant species that inhabit this area. The species listed under the beach and subtidal sand habitat do not include all species found from this zone. The dominant species found along the barrier island beaches in the area between the tides include ghost crabs, amphipods, polychaetes, mantis shrimps, and short-browed mud shrimps (Odum et al. 1974). From the low intertidal to subtidal areas, the major species include speckled crabs, mole crabs, lady crabs, shame-face crabs, long-eyed shrimps, snapping shrimps, blue crabs, sand shrimps, white shrimps, brown shrimps, pink shrimps, moon snails, disk shells, coquinas, cockle shells, sunray shells, ear shells, olive shells, dog whelks, numerous species of polychaetes and numerous

2.2.3.1 Continued

species of small crustacean groups (amphipods, isopods, mysids, and copepods) (Odum et al. 1974, Cerame-Vivas and Gray 1966, Matta 1977).

The major fish species in the waters over these intertidal and subtidal sediment zones include mullets, kingfishes, flounders, spots, spotted seatrout, croaker, anchovies, stingrays and small sharks (Odum et al. 1974, Peterson and Peterson 1979). Many shore birds feed along the beaches and intertidal sandflats (see Section 2.2.4 for discussion of terrestrial wildlife on barrier islands). The upper parts of many of the barrier island beaches are used as nesting sites for the loggerhead seaturtle, a protected species.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.3 Marine Ecology
2.2.3.2 Open-Water Plankton System

THE OPEN-WATER COLUMN IS DOMINATED BY PLANKTON AND PELAGIC FISHES

The nearshore waters contain plankton-based community with associated plankton feeding fish. The phytoplankton consist of diatoms and dinoflagellates and the zooplankton consist of small crustaceans and benthic larvae. These plankton act as the foundation of the food chain for commercially important finfish.

The open-water column zone includes all the open waters over the sedimentary areas from the swash zone of the barrier island beaches to approximately the 50 meter (164 ft) depth contour line. While there is no direct limit or border to the waters along the Atlantic continental shelf, some species are generally restricted to the shallower shelf areas. This section deals with the species which use or feed in these open water areas.

The water column zone is a plankton-based system. The food chain is based upon small plant species (diatoms and dinoflagellates) and small crustacean and larval species (copepods and larval benthic forms) which are the food for numerous fish species. The organic material produced in the plankton community settles to the bottom areas and provides nutrients to the benthic communities.

The plankton community is usually dominated by a few species of both phytoplankton and zooplankton, depending on the season (Roberts 1974). The nearshore coastal zooplankton is usually dominated by the copepods Acartia tonsa and A. clausi (Odum et al. 1974, Sutcliffe 1950). In addition to the copepods, the zooplankton also consists of small shrimps (lucifer shrimps, mysid shrimps and krill shrimps), arrow worms, and the larvae of polychaetes, molluscs, crustaceans and tunicates (see Table 2.2.3.2.a and Sutcliffe 1950). Also, jellyfish and comb jellies are a dominant feature of the zooplankton community.

Table 2.2.3.2.b shows the dominant copepod and chaetognath species for each of the three water column zones in this area (Pierce and Wass 1962, Sutcliffe 1950, Bowman 1971). Just as with the zooplankton, the phytoplankton community is dominated by a few species of diatoms and dinoflagellates. The major inshore phytoplankton species include the diatoms Skeletonema costatum, Nitzschia spp., Rhizosolenia staterfathii, Leptocylindrus danicus, Chaetocerus decipiens, and Thalassionema nitzschioides (Marshall 1981). The total concentration of phytoplankton in the coastal waters of North Carolina will vary, but are often between 100-1000 cells per cubic centimeter (Hulburt and Mackenzie 1971).

Small fish such as anchovies, round scad, butterfish and menhaden feed on the plankton and are eaten in turn by such commercially important species as bluefish, spanish and king mackeral and amberjack (see Section 3.5.3 for fisheries information).

Table 2.2.3.2.a. Composition of the Zooplankton off North Carolina.

Organisms	% Total Zooplankton
Copepodids	44.3
Copepod nauplii larvae	41.2
Tunicate larvae (sea squirts)	5.1
Pelecypod larvae (clams)	3.6
Annelid larvae (worms)	2.3
Gastropod larvae (snails)	1.6
Chaetognaths (arrow worms)	0.8
Medusae	0.2
Barnacle larvae	0.2
Echinoderm larvae (urchins and sea stars)	0.2
Pteropods (sea butterflies)	0.2
Cladocera	0.1
Pelagic tunicates	0.1

Source: Sutcliffe, W. H. 1950.

Table 2.2.3.2.b. Copepod Species and Chaetognath (Arrow Worm) Species Associated by Water Mass.

Water Mass	Copepod Species	Chaetognath Species
Coastal	*Acartia tonsa*	*Sagitta tenuis*
	Labidocera aestiva	*S. hispida*
Shelf	*Paracalanus parvus*	*S. helenae*
	Centropages furcatus	*S. enflata*
	Eucalanus pileatus	
	Temora turbinata	
Oceanic	*Lucicutia flavicornis*	*S. serratodentata*
	Temora stylifera	*S. minima*
	Paracalanus aculeatu	*S. pipunctata*
	Clausocalanus furcatus	*S. hexaptera*
	Calanus minor	*S. lyra*
	Undinula vulgaris	
	Euchaeta marina	

Source: North Carolina Sea Grant Program 1977.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.3 Marine Ecology

2.2.3.3 Natural and Artificial Reefs

REEF COMMUNITIES EXIST IN SMALL PATCHES IN THE NEARSHORE REGION

Natural reefs are reduced in size and distribution in the shallow waters of the marine environment. Artificial reefs and shipwrecks also support the same types of fish and invertebrates that can be found in the natural reefs. The reef communities are important to the local fisheries because they are high production areas for both shellfish and finfish.

In the area south of Cape Hatteras, rock outcroppings are found which support large numbers of sessile (attached) organisms and fishes. These areas are known to local fishermen as live bottoms or snapper banks because of the large numbers of fish that are attracted to these areas for protection and food. In the nearshore zone these live bottom areas are usually small patches of rock outcroppings which are interspersed with sandy sediment habitat. As the distance offshore is increased, these areas become more extensive and the height of reefs increases (inshore reefs are generally less than 1.0 m (3.28 ft) high) (Menzies et al. 1966). Reef areas are usually found in depths up to 30 m (98 ft), but offshore in North Carolina these areas occur in depths of 18 m (50 ft) (U.S. Dept. of Interior 1978 and 1980). Reef communities can be found in two general categories: 1) natural reefs from rock outcroppings and hard bottoms and 2) artificial reefs from sunken ships and created reefs.

Live bottom areas are usually dominated by sessile organisms such as sponges, sea fans, bryozoans, anemones, tunicates, algae, hydroids, gorgonians, star fish, urchins, sessile clams, barnacles and small amounts of hard corals. Because of the large numbers of sessile organisms, these reef communities support numerous associated faunal components (amphipods, isopods, crabs, shrimps, snails, polychaetes). Large numbers of fish are attracted to these areas for food and shelter. The major fish species of commercial or sport fishing interest found over reef areas include groupers, snappers, jacks, sea bass, porgies and grunts (U.S. Dept. of Interior 1978 and 1980). Also many of the pelagic fish (mackerals, cobia, tuna, bluefishes etc.) will feed in these areas.

Another live bottom area also exists in the nearshore marine system. A large commercial concentration of calico scallops is found off the coast of Cape Lookout (U.S. Dept. of Interior 1978 and 1980). These calico scallop beds are dependent on the abundant plankton in the water column. Other invertebrates associated with this community are barnacles, polychaetes, small crabs and many of the other sessile groups mentioned earlier. Some of the same fishes can be found foraging over these areas.

The artificial reefs consist of numerous ship wrecks and near-shore reefs created by man to attract fish. Most of these artificial reefs consist of

2.2.3.3 Continued

cement piles, tires and ships and are located near the various inlets and close to shore (U.S. Dept. of Interior 1978 and 1980). Thus, many of the offshore reef fishes can be caught much closer to shore and within reach of the small sport fisherman boats. Most of the same natural encrusting and attached invertebrates mentioned under natural reefs will also be found here.

U.S. Dept. of Interior maps (1978, 1980) show the location of some of the wrecks. Soon after these wrecks occur, the encrusting organisms begin attaching to the surfaces and the same types of reef communities are established.

The reef communities are high production areas for many species of finfish and shellfish. These areas are extremely important to the local fisheries interests since many species use these areas for protection and as a source of food.

2.2.3.4 Marine Mammals and Reptiles

A NUMBER OF MARINE MAMMALS AND REPTILES, INCLUDING ENDANGERED SPECIES, CAN BE FOUND IN THE STUDY AREA

A total of 27 mammals and 5 reptiles protected by U.S. statute can be found in the marine environment. There are 17 species of whales, 7 species of dolphins, 3 species of seals, and 5 species of sea turtles found from this area. The main food for these species are plankton for whales; fish and invertebrates for seals, dolphins, and sea turtles and algae and seaweed for sea turtles.

Most mammals and reptiles species will range the entire Atlantic and Gulf coasts depending on migratory patterns and time of the year. Information on marine mammal species is represented by species lists, and actual numbers of individual populations are limited (Caldwell and Caldwell 1974, Caldwell and Golley 1965, Golley 1966, Moore 1953, Layne 1965). All marine mammals along the coast of the United States are protected by the U.S. Marine Mammal Protection Act of 1972 which includes a ban on the importation of marine mammal products.

Table 2.2.3.4 shows a list of all marine mammals known to occur along the southeastern Atlantic coast. It is possible that some of these species may not be found in the study area, but because the range of most of these species is large, the possibility exists for the presence of all species (Rice and Scheffer 1968). Three of these species (Atlantic bottlenose dolphin, harbor seal, and California sea lion) are also found in the estuarine region, but the sea lion is thought not to have breeding populations in the area (U.S. Dept. of Interior 1978, 1980). Several of these species are considered endangered including the black right whale, humpback whale, sei whale, fin whale and sperm whale (U.S. Dept. of Interior 1975).

Most of the whales eat plankton and feed in the nearshore area where krill shrimps, mysid shrimps, lucifer shrimps and other zooplankton components occur. The dolphins, seals and some whales feed on the abundant finfish and shellfish that exists in these areas.

The marine reptiles in this study area include five species of sea turtles (Table 2.2.3.4). While all of these sea turtles can be found in the marine area, only the Atlantic loggerhead sea turtle is confirmed as a regular nester along the barrier island beaches in North Carolina. The main food for sea turtles are tunicates, shrimps, crabs, small fish, jellyfish, comb jellies, marine worms, small crustaceans and marine algae. Many of the sea turtles are often associated with the reef communities because of the abundance of food in this habitat. All of these sea turtles are protected under the U.S. Endangered Species Act of 1973 (as amended, 1978).

Table 2.2.3.4. Species of Marine Mammals and Reptiles Known from the North Carolina Coastal Zone.

Common Name	Scientific Name
Marine Mammals	
* Black right whale	* _Eugalena glacialis_
* Humpback whale	* _Megaptera novaeangliae_
* Sei whale	* _Balaeoptera acutorostrata_
Bryde's whale	_B. edeni_
* Fin whale	* _B. physalus_
False killer whale	_Pseudora crassidens_
Killer whale	_Orcinus orca_
Short-finned pilot whale	_Globicephala macrorhyncha_
* Sperm whale	* _Physeter catodon_
Pygmy killer whale	_Feresa attenuata_
Pygmy sperm whale	_Kogia breviceps_
Dwarf sperm whale	_K. simus_
Antillean beaked whale	_Mesoplodom mirus_
True's beaked whale	_Mosoplodom mirus_
Dense beaked whale	_M. densirostris_
Goose beaked whale	_Ziphnus cavirostris_
Rough-toothed whale	_Steno bredanensis_
Risso's dolphin	_Grampus griseus_
Saddleback dolphin	_Delphinus delphis_
Spinner dolphin	_Stenella longirostris_
Bridled dolphin	_S. frontalis_
Spotted dolphin	_S. plagiodon_
Harbor porpoise	_Phocoena phocoena_
California sea lion	_Zalophus califorianus_
Harbor seal	_Phoca vitulina concolor_
Hooded seal	_Cystophora cristata_
Florida manatee	_Trichechus manatus_
Marine Reptiles	
**Atlantic green sea turtle	_Chelonia mydas_
**Atlantic loggerhead sea turtle	_Caretta caretta_
*Atlantic hawksbill sea turtle	_Eretmochelys imbricata_
*Atlantic ridley sea turtle	_Lepidochelys kempi_
*Atlantic leatherback sea turtle	_Dermochelys coriacea_

*Endangered species
**Threatened species

Source: U. S. Department of Interior, Fish and Wildlife Service. 1975; Roberts, M. H., Jr. 1974; N. C. State Museum of Natural History. 1977.

TERRESTRIAL ECOLOGY DICTATED BY HARSH ENVIRONMENTAL CONDITIONS

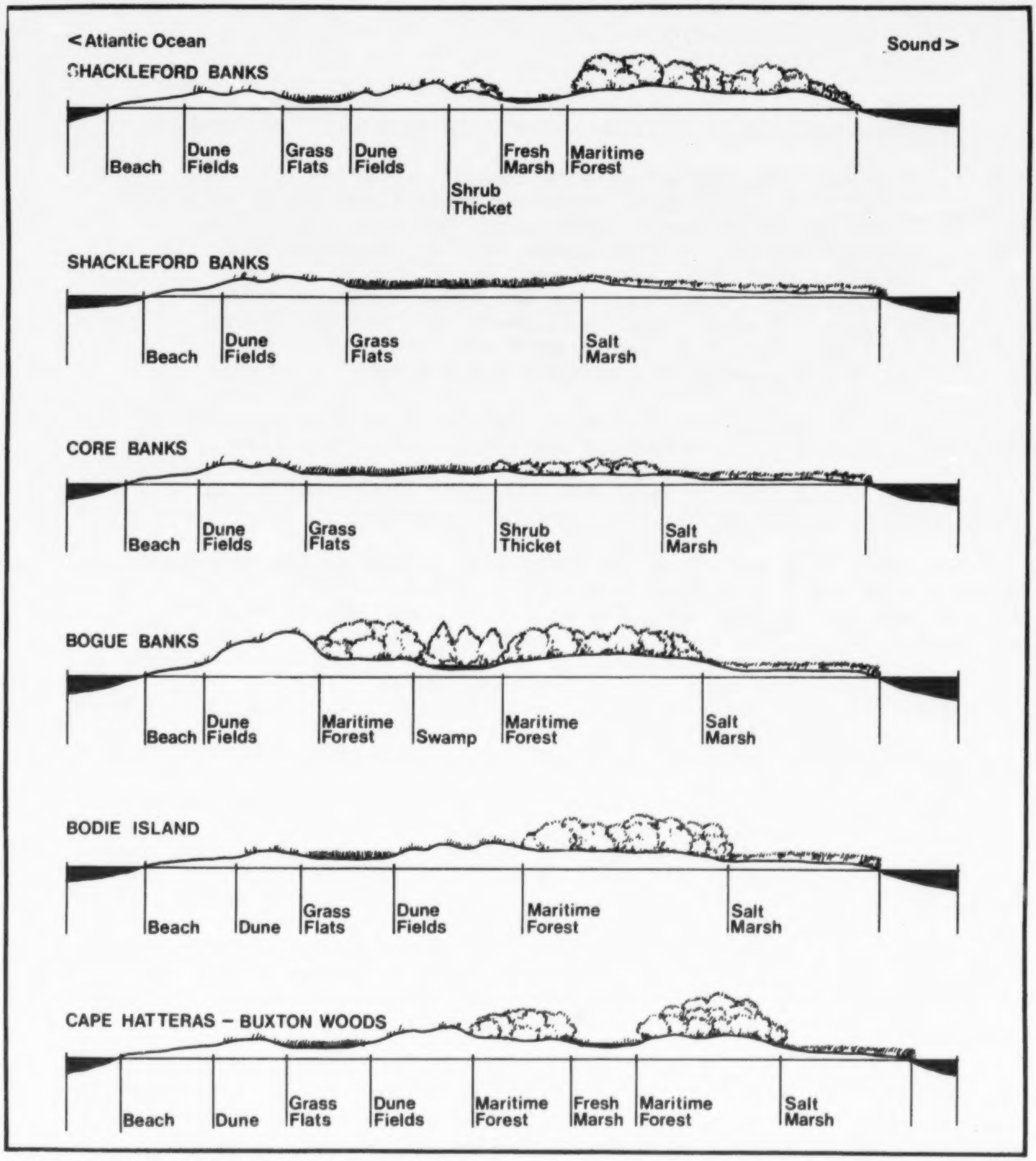
Although the barrier islands contain a variety of terrestrial communities, plant and animals are limited by the harsh environmental conditions. The seven terrestrial communities include five common herb or shrub-dominated types: dunefields, grass flats, shrub thickets, fresh marshes and saltmarshes. The two forest types, maritime forests and swamps, are less common. Wildlife populations are low compared to nearby mainlands, except for birds which are exceptionally abundant and diverse.

Some of the important environmental influences which help determine the terrestrial ecology of the area include winds, salt spray, tides, flooding and dry, unstable and infertile soils. These factors are greatly intensified by periodic storms, such as hurricanes and northeasters, which usually expend their greatest forces on the coastal barrier islands.

The terrestrial ecology of the study area is perhaps best understood in terms of the existing vegetation patterns. Vegetation communities are not only highly visible, but are relatively stable and largely determine the occurrences of wildlife populations. Although a number of studies indicate that the vegetation of specific sites on the barrier islands has changed considerably over the past century (Au 1974, Bordeau & Oosting 1959; Burk 1962; Engels 1952; Lewis 1917), recent evaluations have shown that the natural vegetation patterns tend to maintain a dynamic equilibrium with the environment (Dolan, Godfrey & Odum 1973; Godfrey & Godfrey 1974).

Seven terrestrial communities may be recognized within the barrier islands of North Carolina: dunefields, grass flats, shrub thickets, maritime forests, swamps, freshwater marshes and saltmarshes. Figure 2.2.4.a shows the typical distribution of these community types along profiles at representive sites on the North Carolina coast. All of the terrestrial communities are not usually present at any one location. These communities are not always distinct but will often intergrade between types. For instance, brackish marshes are sometimes found in the transition zones between fresh and saltwater marshes; such ecotones contain elements of both communities and are often higher in diversity (Odum 1971).

Another factor complicating vegetation patterns is the influence of successional development. Succession is the orderly change in species composition and community structure with time, hypothetically culminating in a climax community which is self-perpetuating and in equilibrium with the environment (Odum 1971). On the barrier islands, maritime and mesic forests may be considered the climax vegetation (Au 1974, Burk 1962). However, various environmental factors, such as salt spray or tidal flooding, often act to hinder or prevent succession from reaching a climax state. Figure 2.2.4.b depicts the general successional patterns for terrestrial communities in the study area as influenced by important environmental factors.



< Atlantic Ocean
Sound >
SHACKLEFORD BANKS
Beach
Dune Fields
Grass Flats
Dune Fields
Shrub Thicket
Fresh Marsh
Maritime Forest
SHACKLEFORD BANKS
Beach
Dune Fields
Grass Flats
Salt Marsh
CORE BANKS
Beach
Dune Fields
Grass Flats
Shrub Thicket
Salt Marsh
BOGUE BANKS
Beach
Dune Fields
Maritime Forest
Swamp
Maritime Forest
Salt Marsh
BODIE ISLAND
Beach
Dune
Grass Flats
Dune Fields
Maritime Forest
Salt Marsh
CAPE HATTERAS – BUXTON WOODS
Beach
Dune
Grass Flats
Dune Fields
Maritime Forest
Fresh Marsh
Maritime Forest
Salt Marsh

Figure 2.2.4.a Distribution of Terrestrial Community Types Along Representative Barrier Island Profiles.

Sources: Au, 1974; Godfrey and Godfrey, 1976; U.S.G.S. Topographic Maps.

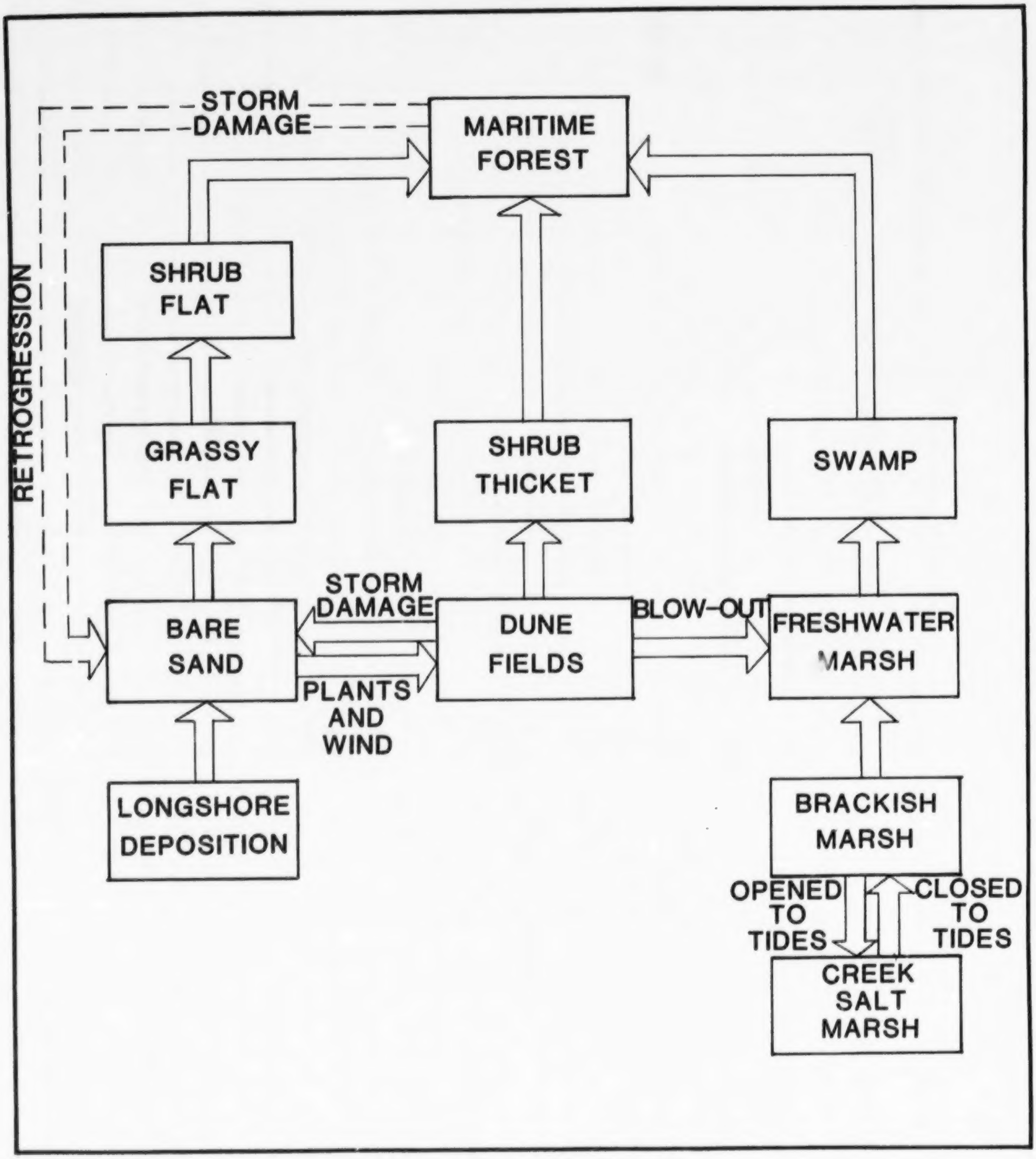

STORM
DAMAGE
MARITIME FOREST
RETROGRESSION
SHRUB FLAT
GRASSY FLAT
SHRUB THICKET
SWAMP
STORM
DAMAGE
BLOW-OUT
BARE SAND
DUNE FIELDS
FRESHWATER MARSH
PLANTS
AND
WIND
LONGSHORE DEPOSITION
BRACKISH MARSH
OPENED
TO
TIDES
CLOSED
TO
TIDES
CREEK SALT MARSH

Figure 2.2.4.b General Successional Trends on the Barrier Islands.

Source: After Au (1974).

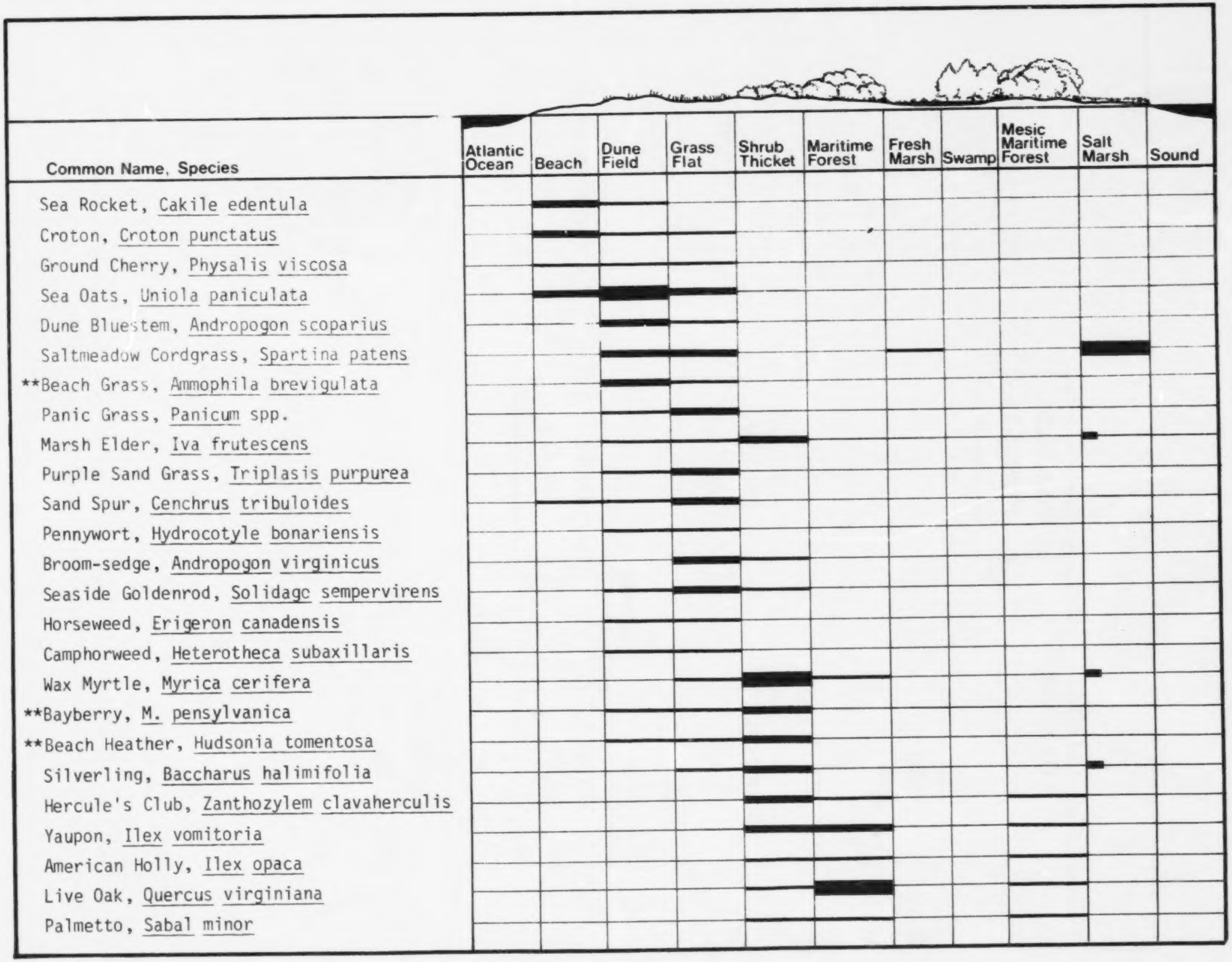
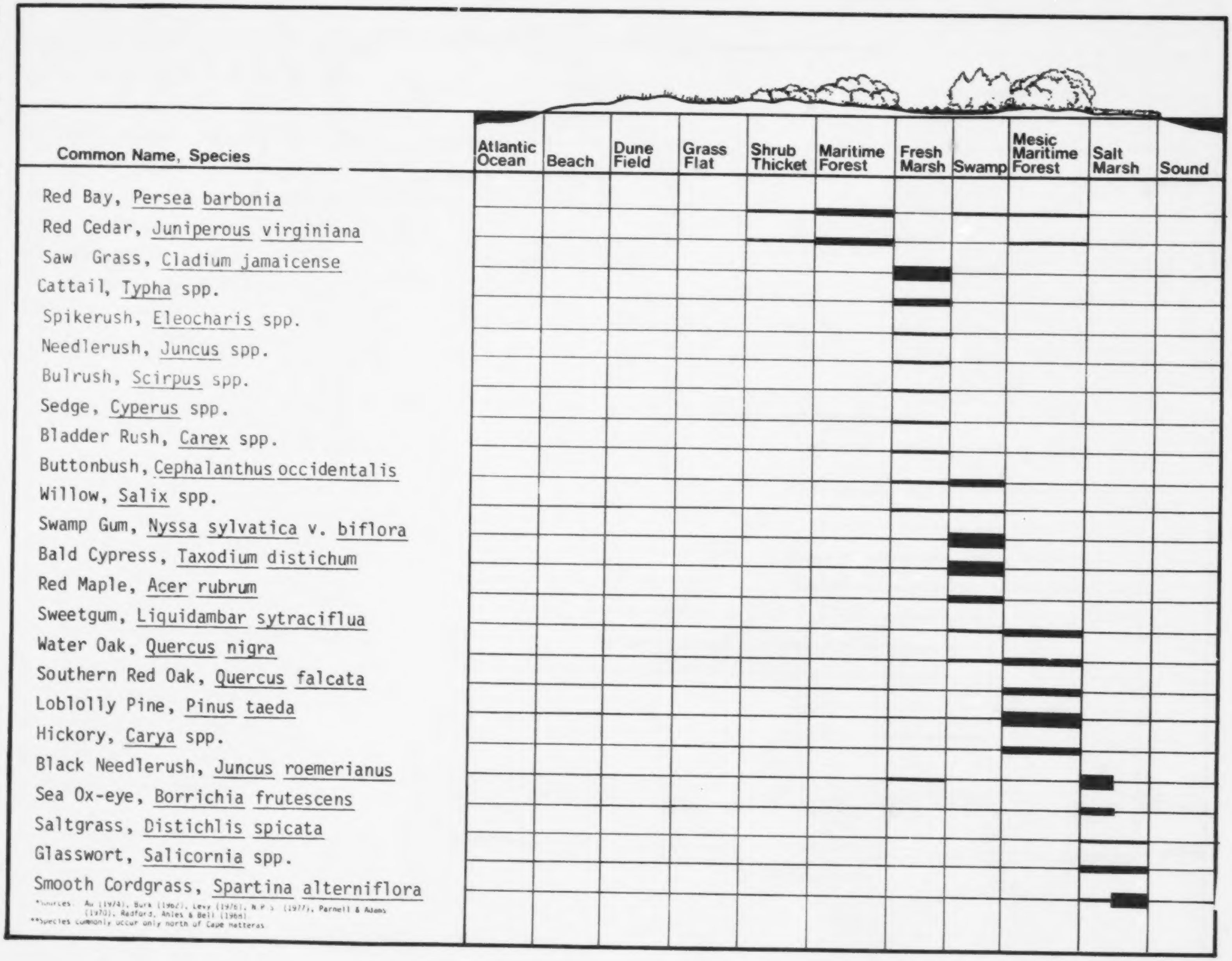


Figure 2.2.4.c. Distribution of Common Plant Species on the Barrier Islands*



*Sources: Au (1974), Burk (1962), Levy (1976), N.P.S. (1977), Parnell & Adams (1970), Radford, Ahles & Bell (1968)

**Species commonly occur only north of Cape Hatteras

Figure 2.2.4.c. (Continued)

Common Name, Species	Atlantic Ocean	Beach	Dune Field	Grass Flat	Shrub Thicket	Maritime Forest	Fresh Marsh	Swamp	Mesic Maritime Forest	Salt Marsh	Sound
Amphibians											
Amphiuma, Amphiuma means							●	●			
Eastern Spadefoot, Scaphiopus holbrooki						●			●		
Southern Toad, Bufo terrestris					●	●	●				
Fowler's Toad, B. woodhousei fowleri			●	●	●	●	●				
Green Treefrog, Hyla cinerea							●	●			
Squirrel Treefrog, H. squirella						●	●	●	●		
Gray Treefrog, H. versicolor						●	●	●	●		
Little Grass Frog, Limnaoedus ocularis							●	●			
E. Narrow-Mouthed Toad, Gastrophryne carolinensis						●	●	●	●		
S. Leopard Frog, Rana utricularia						●	●	●	●		
Carolina Gopher Frog, R. areolata capito					●	●					
Reptiles											
Alligator, Alligator mississippiensis							●	●			
Snapping Turtle, Chelydra serpentina							●	●			
E. Mud Turtle, Kinosternon subrubrum							●			●	
Spotted Turtle, Clemmys guttata							●	●			
Diamondback Terrapin, Malaclemys terrapin							●			●	
Yellow-bellied Turtle, Chrysemys scripta							●				
Atlantic Loggerhead, Caretta caretta	●	●									●
Atlantic Ridley, Lepidochelys kempi	●										
Atlantic Leatherback, Dermochelys coriacea	●	●									
Green Anole, Anolis carolinensis						●		●	●		
Six-lined Racerunner, Cnemidophorus sexlineatus			●	●	●	●					

Figure 2.2.4.d. Amphibians and Reptiles Known from the Barrier Islands*

Common Name, Species	Atlantic Ocean	Beach	Dune Field	Grass Flat	Shrub Thicket	Maritime Forest	Fresh Marsh	Swamp	Mesic Maritime Forest	Salt Marsh	Sound
S.E. Five-lined skink, Eumeces inexpectatus						●			●		
Ground Skink, Leiolopisma laterale					●	●					
E. Glass Lizard, Ophisaurus ventralis			●	●	●	●					
Brown Water Snake, Natrix taxispilota							●	●			
Banded Water Snake, N. fasciata							●	●			
Carolina Saltmarsh Snake, N. sipedon williamengelsi							●			●	
N. Brown Snake, Storeria dekayi					●	●	●	●	●		
Ribbon Snake, Thamnophis sauritus							●	●			
Eastern Hognose, Heterodon platyrhinos			●	●	●						
Pine Woods Snake, Rhadinaea flavilata						●			●		
Eatern Coachwhip, Masticophis flagellum			●	●	●	●			●		
N. Black Racer, Coluber constrictor			●	●	●	●	●	●	●		
Rough Green Snake, Opheodrys aestivus					●	●		●	●		
Yellow Rat Snake, Elaphe obsoleta quadrivittata						●			●		
Greenish Rat Snake, E. obsoleta parallela					●	●			●		
Outer Banks Kingsnake, Lampropeltis getulus sticticeps					●	●			●		
E. Cottonmouth, Agkistrodon piscivorus							●	●			
Carolina Pigmy Rattlesnake, Sistrurus miliarus						●			●		
Canebrake Rattlesnake, Crotalus horridus atricaudatus						●	●	●	●		
E. Diamondback Rattlesnake, C. adamanteus					●	●			●		

*Sources: Conant (1975); Engels (1952); FWS (1980); NPS (1977); Quay (1959); Smith & Parnell (1970); Zing Mark (1978).

Figure 2.2.4.d. (Continued)

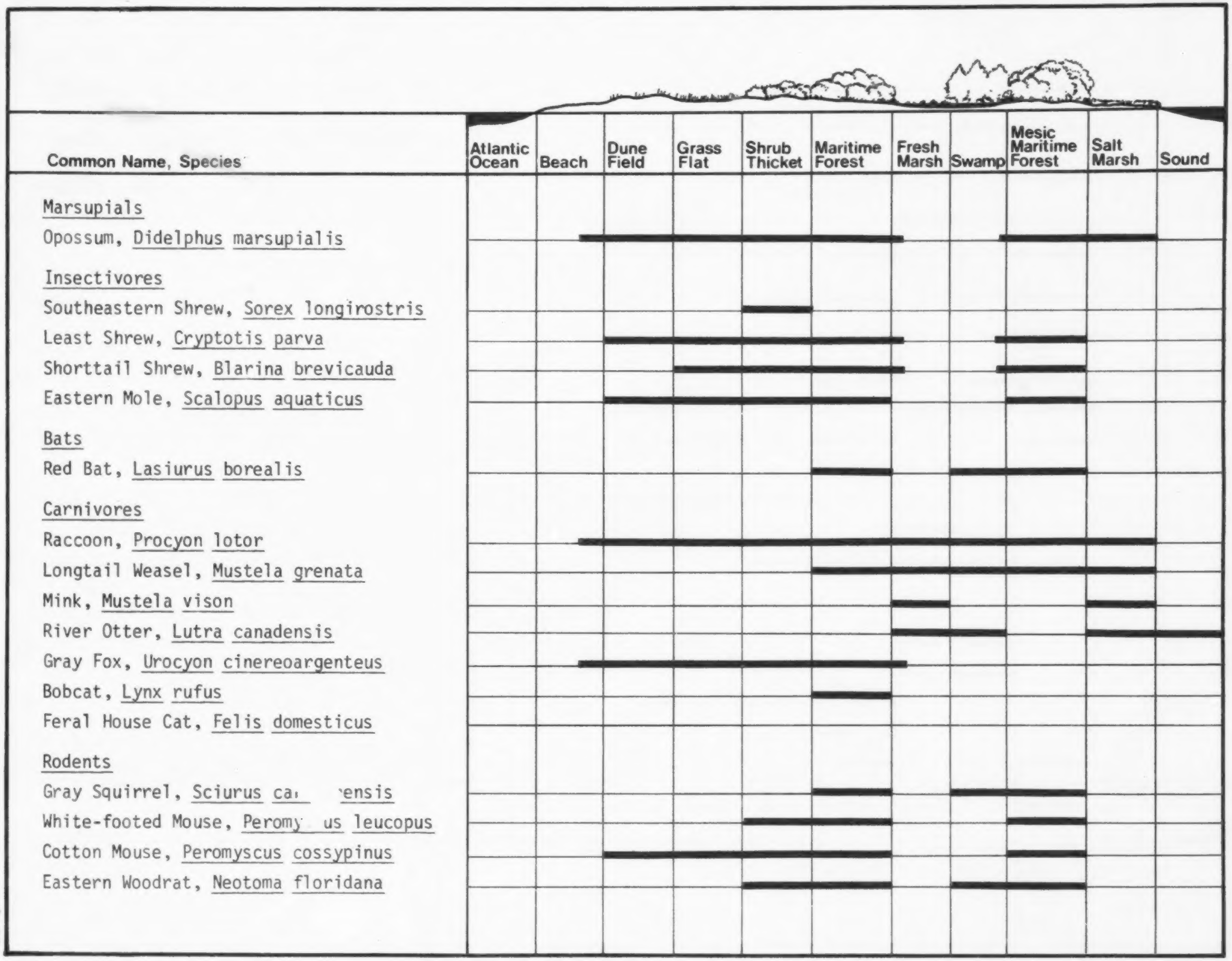


Figure 2.2.4.e. Mammals Known From the Barrier Islands

Common Name, Species	Atlantic Ocean	Beach	Dune Field	Grass Flat	Shrub Thicket	Maritime Forest	Fresh Marsh	Swamp	Mesic Maritime Forest	Salt Marsh	Sound
Rodents (Continued)											
Rice Rat, Oryzomys palustris							━	━		━	
Hispid Cotton Rat, Sigmodon hispidus					━						
Meadow Vole, Microtus pennsylvanicus				━	━		━				
Muskrat, Ondatra zibethica							━	━		━	━
Norway Rat, Rattus norvegicus					━	━	━				
Black Rat, Rattus rattus					━	━	━				
House Mouse, Mus musculus			━	━	━	━	━		━		
Nutria, Myocastor coypus							━	━		━	━
Rabbits											
Eastern Cottontail, Sylvilagus floridanus				━	━	━					
Marsh Rabbit, Sylvilagus palustris							━	━		━	
Hoofed Mammals											
Whitetail Deer, Odocoileus virginianus				━	━	━	━	━	━	━	
Wild Boar, Sus scrofa											
Feral Cow											
Wild Horse											
Feral Sheep											
Feral Goat											

*Documented occurrences on North Carolina barrier islands: South/Smith Island Vicinity (Parnell & Adams 1970; FWS 1980); Central/Cape Lookout Vicinity (Engels 1952; NPS 1977); North/Cape Hatteras Vicinity (Quay 1959).

Figure 2.2.4.e (Continued)

2.2.4 Continued

Although a variety of communities occur on the barrier islands, the vegetational cover and species diversity within these types are relatively low compared to comparable mainland areas. These tendencies are largely due to the harsh environmental conditions prevalent near the coast. Species composition is considerably limited by the inability of many plants to withstand the effects of salt spray (Boyce 1954). Figure 2.2.4.c shows the distribution of important plant species along a hypothetical barrier island profile containing all of the possible terrestrial community types. More detailed discussions of vegetation are included in separate descriptions of the community types found in Sections 2.2.4.2 through 2.2.4.9. Section 2.2.4.1 describes the effects of human influences on the natural terrestrial ecology of the study area.

The abundance of food sources and diversity of habitats tend to encourage an abundance and diversity of animal species. Conversely, the isolation of the islands from mainland areas, relatively young geologic age, limited size, and harsh environmental conditions of the islands tend to reduce animal abundance and diversity. More mobile animals, which can migrate easily from less favorable conditions, have colonized the islands much more successfully than less mobile animals. Consequently birds are the most abundant with over 350 species having been recorded from the North Carolina coast (National Parks Service undated). The species diversity of other animal groups has generally been found to be much lower than that of adjacent mainland areas. Engels (1952) found that the diversities of native amphibians, reptiles and mammals on Shackleford Banks were less than 25 percent of the nearby mainland.

Lists and habitat information for the terrestrial vertebrates are presented in Figure 2.2.4.d (amphibians and reptiles), Figure 2.2.4.e (mammals), and Appendix Table 2.2.4 (birds). Important wildlife nesting areas and significant breeding populations are shown in Figure 2.4.4. Amphibians are poorly represented on the barrier islands, with only 11 species known from the entire coast. This paucity is probably due to the inability of most amphibian species to tolerate salt water conditions. Reptiles include 31 known species, about half of which are snakes. Particularly noteworthy are the protected American alligator and the loggerhead sea turtle which reach their northernmost breeding populations along the North Carolina coast (See Section 2.4.4). The mammal fauna includes about 33 verified species, including six kinds of feral domestic animals. The bird fauna includes about 250 regularly occurring species and about 100 species which are considered rare or accidental. The rich bird diversity can be attributed to the Atlantic Flyway, which is a major migratory route, and the variety of habitats and food sources. Further discussions of wildlife habitat value of the various terrestrial communities on the barrier islands are contained in Sections 2.2.4.2 through 2.2.4.9.

2.2.4.1 Human Influences

HUMAN INFLUENCES MAY SIGNIFICANTLY ALTER THE TERRESTRIAL ECOSYSTEM IN DEVELOPED AREAS

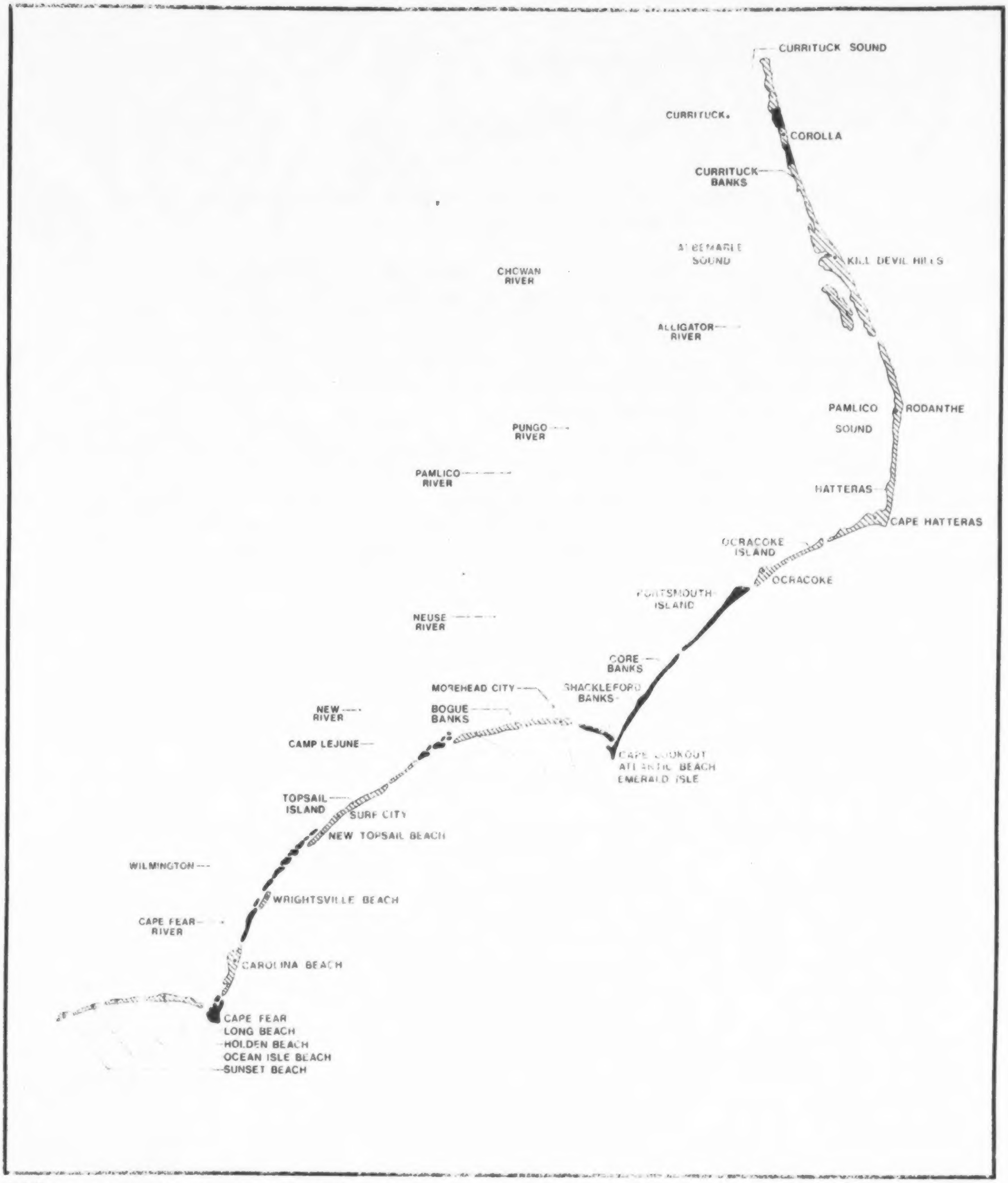
Man-induced factors which have impacted the terrestrial ecosystem include the clearing of vegetation, dune stabilization projects, dredge and fill activities, water pollution, noise and lights, recreational use and the release of domestic animals. The alteration of dune fields and wetland communities is particularly damaging to the barrier island ecology.

The amount of human alteration of terrestrial communities is largely related to the extent of development and accessibility of coastal areas. Figure 2.2.4.1.a shows the general location of developed and undeveloped zones on the barrier islands. Within developed zones, the terrestrial flora and fauna may be impacted from the clearing of vegetation, dune stabilization projects, dredge and fill activities, water pollution, excessive noise and lights and intensive recreational use.

Because of the sandy and unstable soils, the removal of vegetational cover often results in severe erosion from winds or high waters. Dunefields may develop large blowouts; sand dunes may migrate inland, covering other plant communities or man-made structures in the process; denuded dunefields may be more susceptible to overwashes from flooding stormwaters; shorelines may retreat more rapidly. The loss of vegetational cover also destroys the wildlife habitat value of terrestrial communities in most instances.

In many developed and road-serviced areas, especially along the Outer Banks north of Ocracoke Island, dunefields have been stabilized by fences and intensive planting and fertilization of vegetation. Figure 2.2.4.1.b compares the profiles of typical barrier islands with natural and stabilized dune systems. Although dune stabilizations were originally undertaken as conservation measures, recent evaluations conclude that the beneficial effects of such projects are primarily short-term and may ultimately result in long-term negative impacts by altering natural processes (Dolan, Godfrey & Odum 1973; Godfrey & Godfrey 1974). Stabilized barrier islands do not have the dynamic stability of natural barrier islands (Godfrey & Godfrey 1974) and during storms may be subject to more severe beach erosion on the ocean shoreline and intensified flooding on the sound side (Dolan, Godfrey & Odum 1973) as illustrated in Figure 2.4.1.a.

Wetlands on barrier islands are susceptible to impacts from water pollution and dredge and fill activities. Water pollution may result from wastewater discharges, groundwater contamination by faulty septic systems, and urban runoff. Dredge and fill activities, such as finger-fill developments, are particularly damaging and may destroy wetland communities completely.


CURRITUCK SOUND
CURRITUCK.
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
KILL DEVIL HILLS
CHOWAN RIVER
ALLIGATOR RIVER
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH

LEGEND [illegible] Developed Zones of the North Carolina Barrier Islands Source: [illegible]

▨ [illegible]

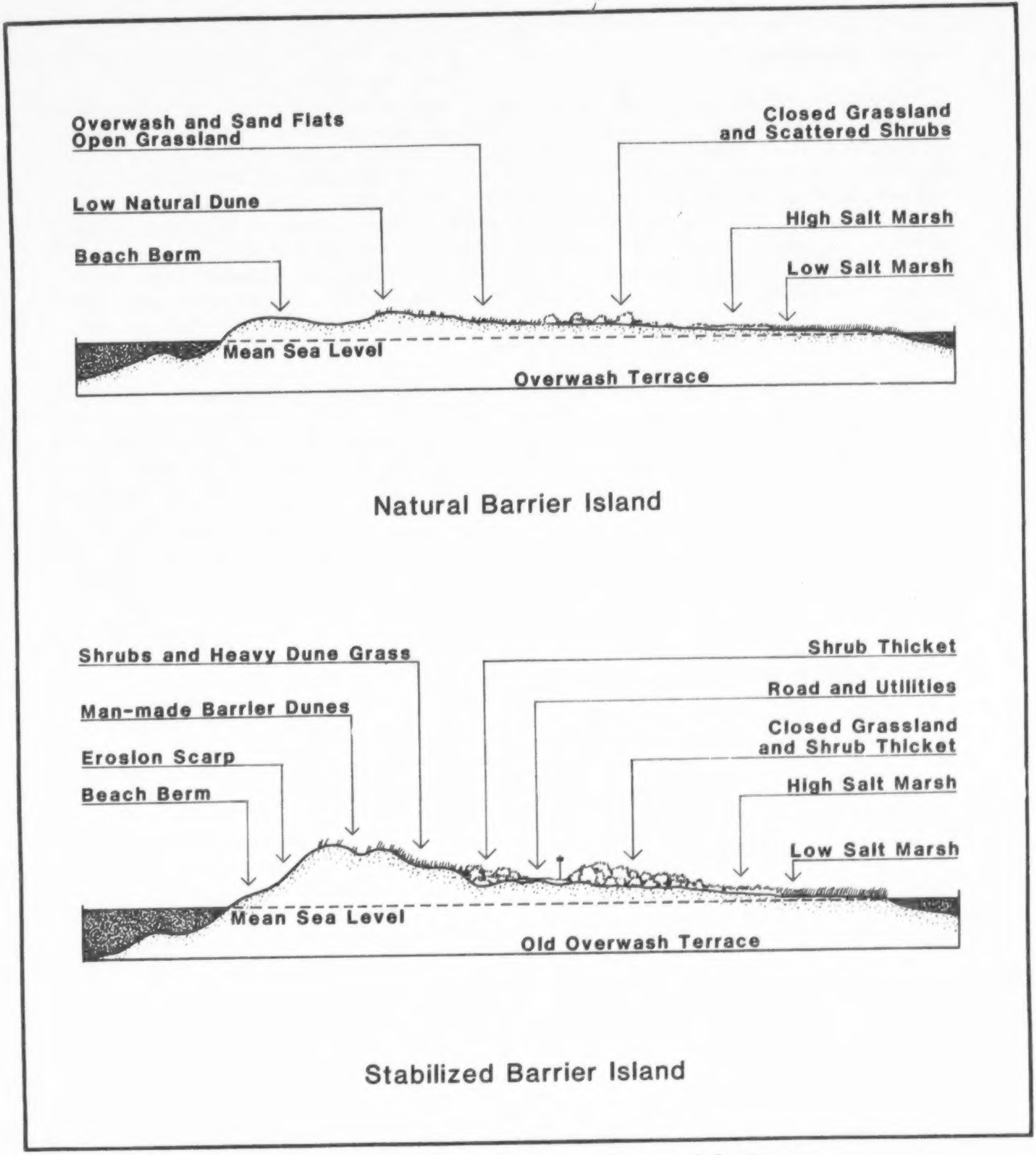
■ [illegible] undeveloped

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

SCALE IN MILES
5 2.5 0 5 10 15 20 30 40


Overwash and Sand Flats
Open Grassland
Closed Grassland and Scattered Shrubs
Low Natural Dune
High Salt Marsh
Beach Berm
Low Salt Marsh
Mean Sea Level
Overwash Terrace

Natural Barrier Island

Shrubs and Heavy Dune Grass
Shrub Thicket
Road and Utilities
Man-made Barrier Dunes
Closed Grassland and Shrub Thicket
Erosion Scarp
High Salt Marsh
Beach Berm
Low Salt Marsh
Mean Sea Level
Old Overwash Terrace

Stabilized Barrier Island

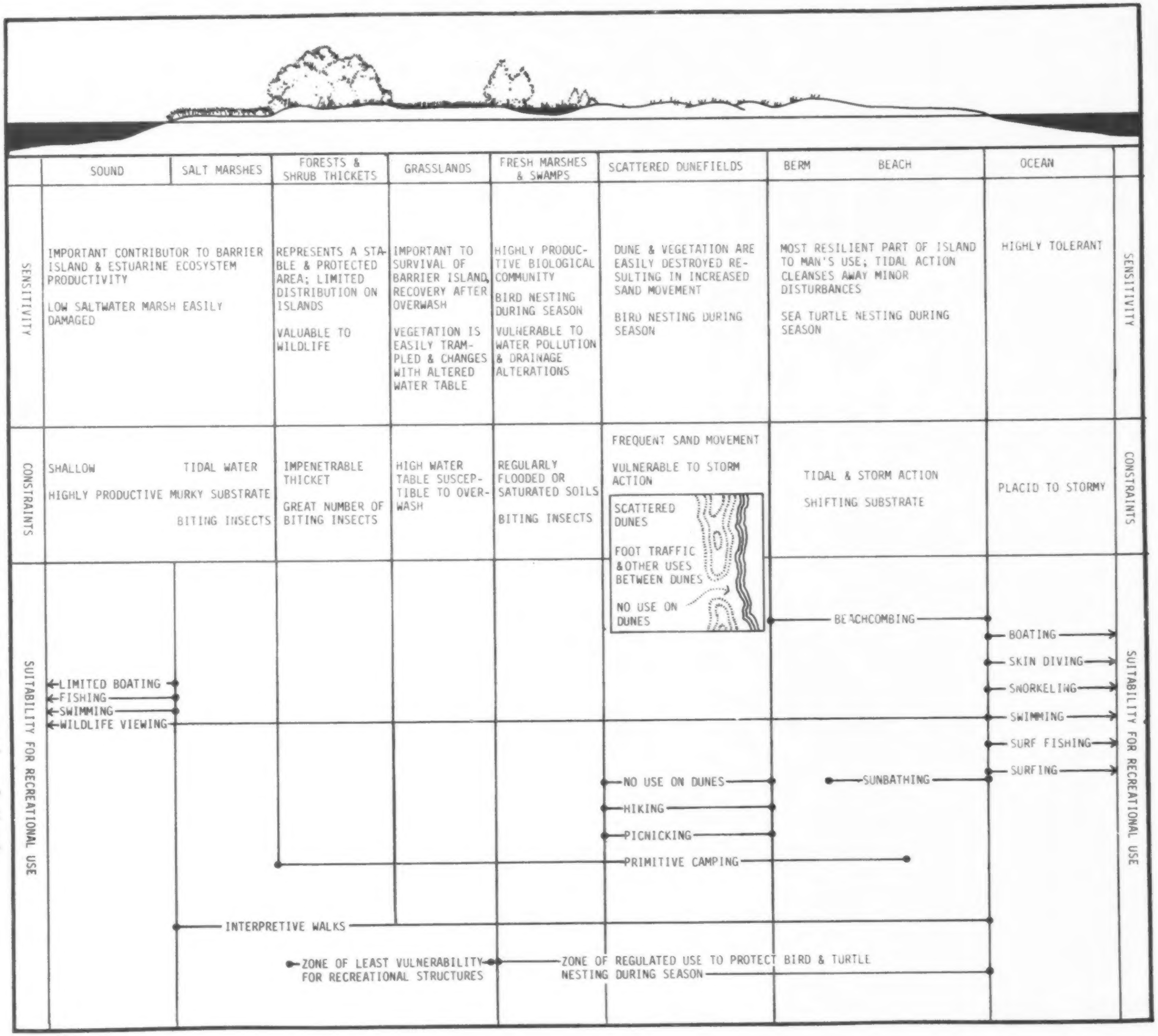
Figure 2.2.4.1.b Comparison of Natural and Stabilized Barrier Islands.
Source: Dolan, et. al., 1973.

2.2.4.1 Continued

Excessive noise and lights may cause considerable impacts to terrestrial wildlife communities. Some animals such as raccoons may occur in or near developed areas, but many wildlife species cannot adapt to living in close proximity to human concentrations. Animals vulnerable to noise and light include bobcats or gray foxes and nesting wildlife populations. Loggerhead sea turtle hatchlings are reported to suffer heavy mortalities on developed barrier islands because of roadkills and disorientation from noise and lights. Adult loggerheads may discontinue nesting on islands that have become developed (Johnson et al. 1974). Intensive recreational use may impact terrestrial communities by creating noise impacts as well as by causing erosion of dunefield vegetation.

The establishment of feral domestic animals has caused adverse impacts to terrestrial ecosystems. Wild horses, cows, hogs, sheep and goats are present on several barrier islands. These animals may cause erosion by over-grazing vegetational cover, contribute to the pollution of ponds and marshes, and compete with native deer populations for food sources. Extreme overgrazing in conjunction with storm events may have caused the severe erosion and submersion conditions now present on Portsmouth Island; however, most authorities believe that the effects of grazing on most barrier islands are minimal compared to natural processes (Godfrey & Godfrey 1976). In addition to these problems, wild boars may destroy loggerhead sea turtle nests or hatchlings (Johnson et al. 1974). Feral house cats are also abundant on many of the barrier islands and compete with native predators by depleting small mammal populations (Engels 1952; NPS 1977; Quay 1959).

Although coastal development is established and certain to continue in many areas, guidelines may be suggested to minimize impacts to the terrestrial ecosystem. The National Park Service (1980) has established recommendations for recreational use activities in Cape Lookout National Seashore which attempt to minimize such impacts. Figure 2.2.4.1.c is adapted from the NPS (1980) recreational use plan and presents the suitability and constraints for development or recreational activities within the various terrestrial communities on barrier islands.


SUITABILITY FOR RECREATIONAL USE
LIMITED BOATING
FISHING
SWIMMING
WILDLIFE VIEWING
BEACHCOMBING
BOATING
SKIN DIVING
SNORKELING
SWIMMING
SURF FISHING
SURFING
NO USE ON DUNES
HIKING
PICNICKING
SUNBATHING
PRIMITIVE CAMPING
INTERPRETIVE WALKS
ZONE OF LEAST VULNERABILITY FOR RECREATIONAL STRUCTURES
ZONE OF REGULATED USE TO PROTECT BIRD & TURTLE NESTING DURING SEASON
SCATTERED DUNES
FOOT TRAFFIC &OTHER USES BETWEEN DUNES
NO USE ON DUNES

	SOUND	SALT MARSHES	FORESTS & SHRUB THICKETS	GRASSLANDS	FRESH MARSHES & SWAMPS	SCATTERED DUNEFIELDS	BERM	BEACH	OCEAN
SENSITIVITY	IMPORTANT CONTRIBUTOR TO BARRIER ISLAND & ESTUARINE ECOSYSTEM PRODUCTIVITY LOW SALTWATER MARSH EASILY DAMAGED		REPRESENTS A STABLE & PROTECTED AREA; LIMITED DISTRIBUTION ON ISLANDS VALUABLE TO WILDLIFE	IMPORTANT TO SURVIVAL OF BARRIER ISLAND, RECOVERY AFTER OVERWASH VEGETATION IS EASILY TRAMPLED & CHANGES WITH ALTERED WATER TABLE	HIGHLY PRODUCTIVE BIOLOGICAL COMMUNITY BIRD NESTING DURING SEASON VULNERABLE TO WATER POLLUTION & DRAINAGE ALTERATIONS	DUNE & VEGETATION ARE EASILY DESTROYED RESULTING IN INCREASED SAND MOVEMENT BIRD NESTING DURING SEASON	MOST RESILIENT PART OF ISLAND TO MAN'S USE; TIDAL ACTION CLEANSES AWAY MINOR DISTURBANCES SEA TURTLE NESTING DURING SEASON		HIGHLY TOLERANT
CONSTRAINTS	SHALLOW HIGHLY PRODUCTIVE	TIDAL WATER MURKY SUBSTRATE BITING INSECTS	IMPENETRABLE THICKET GREAT NUMBER OF BITING INSECTS	HIGH WATER TABLE SUSCEPTIBLE TO OVERWASH	REGULARLY FLOODED OR SATURATED SOILS BITING INSECTS	FREQUENT SAND MOVEMENT VULNERABLE TO STORM ACTION	TIDAL & STORM ACTION SHIFTING SUBSTRATE		PLACID TO STORMY

Figure 2.2.4.1.c Suitability of Terrestrial Communities for Recreational Use*

*Source: Adapted from NPS (1980).

2.2.4.2 Dunefields

DUNEFIELDS ARE VALUABLE BUFFER ZONES BUT ARE VULNERABLE TO ALTERATIONS

Dunefields provide a valuable buffer zone between the open ocean and other barrier island communities. Although dunefield vegetation is adapted to the harsh environmental conditions of this zone, it is vulnerable to human development and recreational use. Vegetational cover and diversity are low, with sea oats being the most important plant species. Wildlife diversity and abundance is relatively low, but the habitat is important for certain species.

Dunefields include the system of sand dunes generally running parallel to and including the upper beaches. Dunefields usually form a zone between the ocean and the island interiors, but sometimes cover almost the entire width of islands or re-occur on relic shoreline dunes behind other communities. Dunefields are regularly exposed to harsh environmental conditions, which are further intensified during storms. Although relatively low in biotic diversity, dunefields are extremely important to the barrier island ecosystem by forming a buffer zone between the ocean and interior island communities, which are less resistant to environmental extremes. Accordingly, the destruction or alteration of dunefields by development or intensive recreational use can result in increased beach erosion, greater susceptibility to overwashes and flooding and the drifting of sand dunes.

The vegetational cover of this community is usually sparse and consists of a low diversity of plants that are adapted to the intense salt spray, high winds, and unstable, infertile and dry sand soils. Plants of this community are well adapted to colonize barren areas formed by ocean overwashes, shifting sand dunes, blow-outs and lands added from shoreline accretion. The common/scientific names and distributions of plant species that typically occur in the dunefield community are shown in Figure 2.2.4.c. The most important and conspicuous plants are sea oats, which on most islands largely dominate this community. Other species that are often abundant include saltmeadow cordgrass and dune bluestem. Sea rocket and croton are notable colonizers of the upper beaches (Parnell & Adams 1970, Au 1974). Different species dominances are present on the stabilized barrier islands from Ocracoke northward. The dunefields on these islands have been intensively planted with beach grass, which replaces sea oats as the dominant species; panic grasses and purple sandgrass are also commonly abundant (Levy 1976, Dolan et al. 1973).

While the dunefields are important to the stability of other island communities, they do not contain a large variety or abundance of wildlife. The paucity of animals is largely due to limited food sources (Parnell & Adams 1970) and harsh environmental conditions Figure 2.2.4.d and 2.2.4.e show the amphibian, reptile and mammal species which utilize dunefields for habitat; Appendix Table 2.2.4 contains this kind of information for birds.

2.2.4.2 Continued

The threatened loggerhead sea turtle is known to nest on the upper beaches of barrier islands from the South Carolina border to Pea Island in North Carolina (FWS 1980, See Figure 2.4.4). Additional endangered sea turtle species also occur in the Atlantic coastal waters (see Table 2.2.5.a) but are not known to nest regularly on North Carolina shores. Other significant animals frequently nesting in the dunefield community include gray foxes (Parnell and Adams 1970) and a variety of shorebirds, such as terns, gulls, plovers, turnstones, black skimmers and oyster catchers (FWS 1980).

2.2.4.3 Grass Flats

GRASS FLATS OFTEN OCCUR IN OVERWASH ZONES

Grass flats occur on low, level grounds often associated with overwash zones. High water tables may be present. Plant species compositions are similar to dunefields but cover is much denser. Many grass flats also contain scattered clumps of shrubs. The wildlife habitat value of this community is relatively low.

Grass flats frequently occur on low, level ground behind dunefield systems and on re-vegetated overwash areas. The water table is frequently high in these areas, and drainage may be impeded during rainy periods or after floods. Grass flats are an abundant community type, especially on narrow and sparsely vegetated barrier islands.

Grass flats contain many of the same plant species which are found in the dunefield community, but species dominances are different and vegetational cover is usually much denser and more diverse. The changes in vegetation are largely related to the reduction in winds and salt spray and the greater availability of moisture in these areas. Although sea oats are frequently an important component of this community, a variety of other plant species also share dominance including saltmeadow cordgrass, seaside goldenrod, panic grasses, purple sand grass, sand spur and broomsedge. Many grass flats, sometimes referred to as closed grasslands (NPS 1980), contain scattered clumps of shrubs such as marsh elder, wax myrtle, silverling, and (above Cape Hatteras) bayberry and beach heather.

Grass flats are of limited value as wildlife habitat because of the relative paucity of food sources and lack of cover. Nevertheless, the field-like conditions of this community contribute to the habitat diversity of barrier islands and are at least occasionally used by many vertebrate species. Amphibian, reptile and mammal species which commonly utilize grass flats are shown in Figures 2.2.4.d and 2.2.4.e; birds using this habitat are listed in Appendix Table 2.2.4.

SHRUB THICKETS ARE THE ONLY WOODY VEGETATION ON SOME BARRIER ISLANDS

Shrub thickets occur on lands near the coast that are relatively well protected from wind and salt spray. This community often intergrades with dunefields, grass flats and maritime forests. Vegetational cover and diversity are fairly high and dominated by shrubs such as wax myrtle. Wildlife habitat value is moderately high.

Shrub thickets generally occur in low, level areas similar to grass flats but with greater protection from salt spray and winds. Thickets are often interspersed with grass flats and sometimes occur on the lee side of well developed dunefields. Shrub communities are found on probably all of the barrier islands and are sometimes quite extensive; on some islands, these thickets are the only woody vegetation.

Shrub thickets are a fairly diverse community often having a dense vegetational cover. Plants usually sharing dominance in this community include wax myrtle, marsh elder, silverling, Hercule's club, yaupon, and (above Cape Hatteras) bayberry and beach heather. Herbs common to the grass flats and dunefields and stunted trees common to the maritime forest frequently extend into the shrub thickets. Hence, this community may be considered an ecotone between the herb and forest zones.

Shrub thickets are relatively important wildlife habitats, particularly on the many barrier islands which lack significant forested areas. The dense vegetational cover is valuable to many animals, such as cottontail rabbits and migrating passerine birds. Amphibians, reptiles and mammals utilizing this habitat are shown in Figures 2.2.4.d and 2.2.4.e; associated birds are listed in Appendix Table 2.2.4.

2.2.4.5 Maritime Forests

MARITIME FORESTS ARE VALUABLE UPLAND COMMUNITIES BUT ARE LIMITED IN EXTENT

Maritime forests occur on protected inland sites on the barrier islands. Because of environmental factors or clearing by humans, not all of the islands contain these forests. Vegetational cover is dense and usually dominated by live oaks. Wildlife habitat value is high.

Maritime forests generally occur on the interior and inland sides of barrier islands where the coastal winds and salt spray are somewhat reduced. Such forests are considered the climax vegetation for most of the North Carolina coast (Bordeau & Oosting 1959, Au 1974), and accordingly are well-developed only in areas that have been relatively undisturbed. Many of the barrier islands do not contain any significant maritime forest stands because of narrow island widths (preventing an adequate reduction of environmental factors), destruction from severe storms, burial by wandering sand dunes, fires and cutting of forests for timber or coastal developments (Bordeau & Oosting 1959). Barrier islands which contain sizable stands of maritime forests include Smith Island, Bogue Banks, Shackleford Banks, Hatteras Island at Buxton Woods, and Bodie Island near Nags Head (Bordeau & Oosting 1959, Burk 1962, Parnell & Adams 1970, Au 1974).

Characteristic features of the maritime forests are an abundance of sclerophyllous (leathery-leaved) evergreens, vines, and epiphytes, with a relative scarcity of herbaceous plants (Johnson et al. 1974). Live oak trees are typically the most conspicuous element of this community and often will almost entirely dominate these forests with their dense canopies. Other woody plant species which are commonly associated with maritime forests include red cedar, loblolly pine, red bay, yaupon, wax myrtle, palmetto, American holly, and Hercule's club. In a few locations where site conditions are particularly favorable, successionally advanced maritime forests have developed. Such mesic forests contain a higher diversty of plants than typical maritime forests and are not solely dominated by live oaks. Tree species which frequently co-dominate these forests include loblolly pine, hickories, Southern red oak, sweetgum, water oak and live oak (Burk 1962). Significant mesic maritime forest stands are reported to occur on Bogue Banks, Buxton Woods, and Nags Head Woods (Burk 1962).

Maritime forests contain the most abundant and diverse wildlife populations of the upland barrier island communities. These forests are the primary habitat for animals such as gray squirrels, bobcats and many passerine birds. A number of terrestrial animal species are known exclusively from well-developed maritime forest stands. The only significant population of whitetail deer on the Outer Banks occurs at Buxton Woods (Quay 1959, FWS 1980). Amphibians, reptiles and mammals that frequently occur in this habitat are shown in Figures 2.2.4.d and 2.2.4.e; associated birds are listed in Appendix Table 2.2.4.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT
2.2 Ecological Inventory
2.2.4 Terrestrial Ecology
2.2.4.6 Swamps

SWAMPS ARE VALUABLE WETLAND COMMUNITIES BUT RARELY OCCUR ON BARRIER ISLANDS

Swamps are forested wetlands that occur in sheltered, but poorly drained locations. Significant stands occur at only a few locations on the barrier islands. The high diversity, cover and productivity of plants result in this community being very valuable as wildlife habitat.

Swamps are wetland communities dominated by woody vegetation. Swamps usually occur in low swales and depressions that are regularly flooded by freshwater from impeded drainage or high water tables. On the barrier islands, swamps are very limited in extent, being most common in wet areas within maritime forest stands. Significant occurrences of this community type are located at Carolina Beach, Bogue Banks, Cape Hatteras at Buxton Woods, and Bodie Island near Nags Head (N.C. Natural Heritage Program, undated). Developments occurring in swamps may require permits from the Army Corps of Engineers, which regulates such wetlands under Section 404 of the Federal Water Pollution Control Act (FWPCA) of 1972 (ACOE 1978).

Swamps are highly productive and diverse plant communities. Bald cypress and swamp gum are typically the dominant plant species at very wet sites, but red maple, sweetgum willows, and buttonbush may also be important. Herbaceous plant cover is usually limited but may include species typical of freshwater marshes. A common characteristic of all swamp vegetation is the ability to tolerate flooded or saturated soil conditions.

Due to their high productivity, diversity, dense cover and abundance of fresh water, swamps are valuable wildlife habitats. A greater variety of animals utilize swamps than any of the other interior barrier island communities except freshwater marshes. Amphibian, reptile and mammal species utilizing swamps which are known from the barrier islands of North Carolina are shown in Figures 2.2.4.d and 2.2.4.e; associated bird species are listed in Appendix Table 2.2.4. Particularly noteworthy are the various species of wading birds (herons, egrets, rails and ibis) which often nest in swamps, sometimes forming large colonies or rookeries (see Figure 2.4.4). The threatened American alligator sometimes occurs in swamps.

2.2.4.7 Freshwater Marshes

FRESHWATER MARSHES ARE VALUABLE WETLAND COMMUNITIES THAT ARE COMMON ON BARRIER ISLANDS

Freshwater marshes are herb-dominated wetlands occurring in poorly drained locations. Although often limited in size, freshwater marshes are common throughout the barrier islands. The high diversity and productivity of plants results in this community being very valuable as wildlife habitat.

Freshwater marshes are wetland communities dominated by herbaceous vegetation. These marshes commonly occur in low swales and depressions that are regularly flooded by freshwater from impeded drainage or high water tables. Some of these areas may contain brackish water. Freshwater marshes are found throughout the barrier islands and often interspersed within other community types. Although usually small in size, extensive freshwater marshes occur at Cape Hatteras, Pea Island and Bodie Island near Nags Head (Burk 1962). Freshwater marshes are vulnerable to pollution from discharges, groundwater contamination and runoff. Developments occurring in marshes may require permits from the Army Corps of Engineers, which regulates such wetlands under Section 404 of the FWPCA of 1972 (ACOE 1978).

Freshwater marshes are highly productive and support diverse plant communities. A common characteristic of all marsh vegetation is the ability to tolerate flooded or saturated soil conditions. Although communities at different sites may vary considerably in species compositions, plants which are usually dominant or abundant in freshwater marshes include saw grass, cattails, spikerushes, needlerushes, bulrushes, sedges and bladder rushes. Woody shrubs, such as buttonbush and willows, may also be important, especially around the edges of marshes.

Because of the high productivity and diversity of vegetation and the abundance of fresh water, marshes are valuable wildlife habitats. A greater variety and abundance of wildlife utilize freshwater marshes than any of the other barrier island communities. Figures 2.2.4.d and 2.2.4.e show the amphibian, reptile and mammal species known from the barrier islands which use freshwater marshes; Appendix Table 2.2.4 lists the bird species associated with this community. Particularly noteworthy are the large variety of wading birds (herons, egrets, rails and ibis) and waterfowl (ducks and geese) which feed and nest in freshwater marshes, sometimes forming large concentrations. Freshwater marshes are also the primary habitat of the American alligator, where it occurs on the barrier islands (see Figure 2.4.4).

2.2.4.8 Saltmarshes

SALTMARSHES ARE EXTENSIVE WETLAND COMMUNITIES THAT ARE VALUABLE TO TERRESTRIAL AND MARINE ECOSYSTEMS

Saltmarshes are herb-dominated communities that are periodically flooded by saltwater. Extensive stands of saltmarshes occur on the protected inland shores of barrier islands. The high productivity of plants results in this community being very valuable to the wildlife of both terrestrial and marine ecosystems.

Saltmarshes are wetland communities dominated by herbaceous plants which are periodically inundated by tidal fluctuations of saltwater. Saltmarshes are abundant in the study area, being most extensive on low wave-energy shores on the inland sides of barrier islands. Due to their high productivity, these are valuable ecological communities and provide a basis for both terrestrial and marine food webs.

Because of their drainage characteristics, saltmarshes may be vulnerable to water pollution and dredge and fill activities. Developments occurring in saltmarshes may require permits from the Army Corps of Engineers, which regulates such wetlands under Section 404 of the FWPCA of 1972 (ACOE 1978). Under existing state law, permits may also be required from the Coastal Resources Commission for dredge and fill activities and development in a designated Area of Environmental Concern (see Section 3.6.1.4).

Saltmarsh vegetation is relatively low in diversity but high in productivity. The vegetation of this community typically occurs in zones determined by the regularity of tidal flooding; each zone is usually dominated by only a few plant species. Low saltmarshes are almost entirely dominated by smooth cordgrass and are regularly flooded by tides. High saltmarshes occur on slightly higher grounds, which are inundated less frequently, and are largely dominated by black needlerush or saltmeadow cordgrass. Other plant species which are frequently abundant in the saltmarshes include the glassworts, saltgrass and sea ox-eye. In the transition areas between saltmarshes and upland communities, a shrub zone of wax myrtle, marsh elder and silverling is often present.

Saltmarshes support immense populations of invertebrates, which ultimately rely on the plants of this community for food sources as well as nursery grounds. These invertebrates, in turn, provide food for an abundance of marine, estuarine, and terrestrial wildlife. Amphibians, reptiles and mammals known from the North Carolina barrier islands which utilize saltmarshes are shown in Figures 2.2.4.d and 2.2.4.e; associated bird species are listed in Appendix Table 2.2.4.

Section 2.2.2.2 discusses saltmarshes from the aquatic viewpoint. Figure 2.2.2 indicates invertebrates and fishes associated with saltmarshes.

A NUMBER OF PROTECTED ANIMAL AND PLANT SPECIES OCCUR IN THE STUDY AREA

Species may be protected by federal and/or state laws. Protected species may be classified as endangered, threatened or species of special concern, depending on their rarity. Protected species in the study area include as many as 18 species of animals and 13 species of plants.

As a result of public concern about the conservation of the nation's native flora and fauna, the United States Congress passed the Endangered Species Act of 1973 (P.L. 93-205) which provides for the preservation of endangered and threatened species of wildlife, fish, and plants. This law not only initiated the establishment of a federal list of endangered and threatened species but also encouraged the states to enact their own endangered species legislation.

Based on the federal Endangered Species Act, two categories of protected species are recognized: endangered and threatened. Endangered refers to those species which are in danger of extinction throughout all or a significant part of their range. Threatened refers to those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range. Through a process of nomination and careful review, the U.S. Fish and Wildlife Service has published a federal list of endangered and threatened species.

As a response to the need for more localized protection, the State of North Carolina has prepared its own legislation. With regard to animals, state protection covers the same species listed by the federal government. However, the North Carolina Plant Protection and Conservation Act provides protection for other plant species in addition to the federal list. The meanings of the endangered and threatened classifications as defined by North Carolina are essentially the same as the federal definitions, but an additional category is recognized by the State. Special concern species are plants which require monitoring by the State but may be collected and sold under specified regulations.

In addition to the state and federal regulations, the North Carolina State Museum of Natural History has published the proceedings of a 1975 symposium on Endangered and Threatened Plants and Animals of North Carolina, with contributions from members of the scientific community throughout the state. Although the status classifications used in this publication do not necessarily agree with official state and federal lists, this book contains valuable information concerning the rare plants and animals of North Carolina.

Protected animal species known from the coastal region of North Carolina are listed in Table 2.2.5.a. Habitat and distribution information is also provided for the more likely species.

2.2.5 Continued

Protected plant species known from the coastal region of North Carolina are listed in Table 2.2.5.b. Of these species, only the Carolina lilaeopsis, loose watermilfoil and dwarf bladderwort are verified or very likely to occur on the barrier islands. Proper habitat conditions exist on the islands for species such as Carolina spleenwort, Chapman's sedge, sarvis holly, white wicky and spring-flowering goldenrod, but verified occurrences are not known. Species such as riverbank sandreed, rough-leaf loosestrife, Carolina goldenrod, wireleaf dropseed and Carolina trillium are known from coastal counties but probably do not occur on the barrier islands due to a lack of proper habitat conditions.

Table 2.2.5.a. Protected Animals known from the Coast of North Carolina.

Group Common Name, (Species)	Status*	Habitat	Known Occurrence (Counties)
BIRDS			
Peregrin falcon (*Falco peregrinus tundrius*)	E	Near coastal waters	All coastal counties
Bald Eagle, (*Haliaeetus leucocephalus*)	E	Near wetlands, lakes and seacoasts	Brunswick, Hyde, Carteret, Dare
Brown Pelican, (*Pelecanus occidentalis*)	E	Estuarine & marine waters	Brunswick, New Hanover, Pender Onslow, Carteret, Hyde, Dare
Red-cockaded Woodpecker, (*Picoides borealis*)	E	Mature pine forests	Brunswick, New Hanover, Pender, Onslow, Carteret
REPTILES			
American alligator, (*Alligator mississippiensis*)	E	Freshwater ponds, marshes & swamps	Brunswick, New Hanover, Pender, Onslow, Carteret, Hyde, Dare
**Loggerhead turtle, (*Caretta caretta*)	T	Estuarine & marine waters (Nests on barrier island beaches)	Brunswick, New Hanover, Pender Onslow, Carteret, Hyde, Dare, Currituck
MAMMALS			
** Florida Manatee (*Trichechus manatus*)	E	Estuarine waters	Brunswick
FISH			
Shortnose Sturgeon (*Acipenser brevirostrum*)	E	Estuarine & marine waters	

*Status: E = Endangered, T = Threatened. Source: N. C. Natural Heritage Program.

**Other protected sea turtles and marine mammals are known to occasionally range through coastal waters; these species include the Atlantic Ridley Turtle (*Lepidochelys kempii*), Green Turtle (*Chelonia mydas*), Hawksbill turtle (*Eretmochelys imbricata*), Leatherback Turtle (*Dermochelys coriacea*), Blue Whale (*Balaenoptera musculus*), Finback Whale (*Balaenoptera physalus*), Humpback Whale (*Megaptera novaeangliae*), Right Whales (*Eubalaena* spp.), Sei Whale (*Balaenoptera borealis*), and Sperm Whale (*Physeter catodon*).

Table 2.2.5.b. Protected Plants Known from the Coast of North Carolina.

Common Name, (Species)	Status*	Habitat	Known Occurrence (Counties)
Carolina spleenwort fern, (Asplenium heteroresiliens)	E	Calcareous sandstone & marl outcrops	New Hanover
Riverbank sandreed, (Calamovilfa brevipilis)	T	Freshwater marshes & bogs, savannahs	Brunswick, Onslow, Carteret
Chapman's sedge, (Carex chapmanii)	T	Dry sandy woods & roadsides	Brunswick, New Hanover
Sarvis holly, (Ilex amelanchier)	SC-E	Swamps	Brunswick, Pender
White wickey, (Kalmia cuneata)	SC-E	Swamps, freshwater marshes, pocossins	Pender
Carolina lilaeopsis (Lilaeopsis carolinensis)	T	Freshwater marshes & ponds	Brunswick, New Hanover, Dare Currituck
Rough-leaf loosestrife, (Lysimachia asperulaefolia)	E	Savannahs, pocossins	Brunswick, Pender, Onslow, Carteret
Loose watermilfoil, (Myriophyllum laxum)	T	Freshwater ponds & marshes	Brunswick, Carteret
Carolina goldenrod, (Solidago pulchra	E	Savannahs, pocossins	Brunswick, Pender
Spring-flowering goldenrod, (Solidago verna)	E	Freshwater bogs & marshes, savannahs, pine flatwoods	Brunswick
Wireleaf dropseed, (Sporobolus teretefolius)	T	Savannahs, pine barrens	Brunswick, Onslow
Carolina trillium, (Trillium pusillus	E	Moist woods	Pender
Dwarf bladderwort, (Ultricularia olivacea	T	Freshwater ponds & marshes	Brunswick, New Hanover, Carteret

*Status: E = Endangered, T = Threatened, SC-E = Special Concern/Endangered

Sources: N.C. Department of Agriculture; N.C. Natural Heritage Program; Radford, Ahles and Bell, 1968.

NORTH CAROLINA COASTAL TOPOGRAPHY, GEOLOGY AND SOILS ARE REPRESENTED BY A NUMBER OF COMPONENTS

Topography, geology and soils have a major controlling factor in the development on barrier islands. Portions of these islands are in a state of constant change. While these changes may be slight in most islands, others have been significantly modified in a few years.

Each of the major components (topography, geology and soils) can be separated into a terrestrial and marine component. The following sections present the information regarding the barrier islands of North Carolina as it pertains to these components. In general, these islands exhibit constant change along their margins from erosion and accretion. These changes can create problems in the development of these islands.

The topography, geology and soils of these islands will determine what wastewater management alternatives can be used. Treatment plants and collection systems must be located in areas protected from flooding, storms and seasonal high water tables. The suitability of soils for effluent disposal with soil absorption systems must be analyzed. The offshore marine region of North Carolina is dotted with numerous outcroppings which support large numbers of fishes. Negative impacts to these resources could limit possible outfall considerations.

The following sections present the terrestrial and marine information on topography, geology and soils.

2.0 DESCRIPTION OF NATURAL ENVIRONMENT

2.3 Topography, Geology and Soils

2.3.1 Terrestrial Topography

NORTH CAROLINA HAS THE MOST EXTENSIVE BARRIER ISLAND SYSTEM ON THE EASTERN SEABOARD

The topography of the barrier islands consists of several major features and includes beaches, dunes, high grounds and flats. Wind and wave action continually alter these topographic features.

The North Carolina barrier island chain stretches for a length of approximately 483 km (300 mi). Although the lengths of the islands are highly variable, they commonly are 1.61-4.83 km (1.0-3.0 mi) in width. Depending on their orientation to ocean currents, wave action and prevailing winds, their topography varies from that of low, narrow islands with almost no dunes, to islands with high topography and extensive dune formation.

The topography is also subject to seasonal changes. During the summer the beaches are typically wider due to sand build up by the prevailing currents that parallel the coast. During the winter and in large summer storms, wave action and strong backwash remove sand from the beaches, resulting in narrower beaches and development of offshore sandbars.

The topography of the barrier islands is comprised of several distinct features. The foreshore is the relatively smooth portion of the beach that extends from the normal low tide level to the normal high tide level. At the high water mark is the berm which is normally indicated by a well-marked break in slope. From this point inland to the farthest point reached by waves is the rougher but relatively flat backshore. Beyond the point where the topography is not normally affected by waves, dunes are commonly found. Behind the dunes and above the high tides are the barrier flats, which may contain stands of trees and grasslands. Between the barrier flats and above mean sea level are the salt marshes. Past the salt marshes toward the sound are the tidal flats, which are below mean sea level. Both the salt marshes and tidal flats have relatively shallow slopes.

In many developed areas, structures have either been situated on dunes or on sites where natural dunes have been removed prior to construction. As can be seen today on several islands, severe damage has occurred where erosion has undermined structural supports. In some cases structures on the ocean front have been destroyed during storms because there are no dunes for protection. In some communities, extensive clean-up operations are required where wind-blown sand from disturbed dunes has encroached on structures situated too near the dunes. An extensive report on location of structures with respect to barrier island features is presented in Pilkey, Neal and Pilkey (1978).

UNCONSOLIDATED SEDIMENTS DOMINATE THE GEOLOGY OF THE REGION

Barrier islands are in a state of dynamic equilibrium with the natural environment. Their structure and geographical location are affected predominantly by storms, sea-level fluctuations, availability of beach sand and man's activities.

Several theories have been proposed to explain the formation of barrier islands. For North Carolina, the most generally accepted theories include formation by spit accretion/inlet breaching and the drowning of mainlands/beach ridges (Godfrey and Godfrey 1976). Another theory, which proposes the gradual accumulation of surplus offshore sediments is considered more controversial (Godfrey and Godfrey 1976). Figure 2.3.2 illustrates these different island formation theories.

The information provided in this section is summarized from the book From Currituck to Calabash (Pilkey, Neal and Pilkey 1978) which contains detailed descriptions of the geology and geomorphology of the North Carolina barrier islands. The barrier islands had their origin about 15,000 years ago when the sea level was 76 m (250 ft) or more below the present sea level during the last major ice age. Beach ridges (dunes) were formed by wave and wind action along the coastline, which was 80.5 km (50 mi) seaward of its present position. As the sea level rose when the continental ice sheet melted, the beach ridges were breached and the low lying areas behind the dunes were flooded, forming lagoons or sounds; then the beach ridges became islands. With the continued rise of the sea level, the islands migrated to their present position.

Although the barrier islands may have had a common origin, the mechanisms that shape each island may vary substantially even between adjacent barrier islands. This is particularly evident in the case of Core Banks and Shackleford Bank. Core Banks is a low, narrow island with almost no dunes while Shackleford is a high, forested island with extensive dune formation. The prevailing wind direction on these is approximately north or south. Since Core Banks is oriented north and south, the wind usually blows sand coming in from fair-weather waves up or down the length of the island. Shackleford Banks, however, is oriented east and west, with the prevailing winds blowing sand across the island at least part of the year, thus building up dunes and increasing the height and width of the island.

The major factors influencing the changing barrier island formations are summarized as follows:

- Along the North Carolina coast sea-level is presently rising at an estimated rate of about .3 m (1 ft) per century. This results in the seaward sides of the barrier islands experiencing beach erosion.

- On a few narrow, low barrier islands, the landward sides of barrier

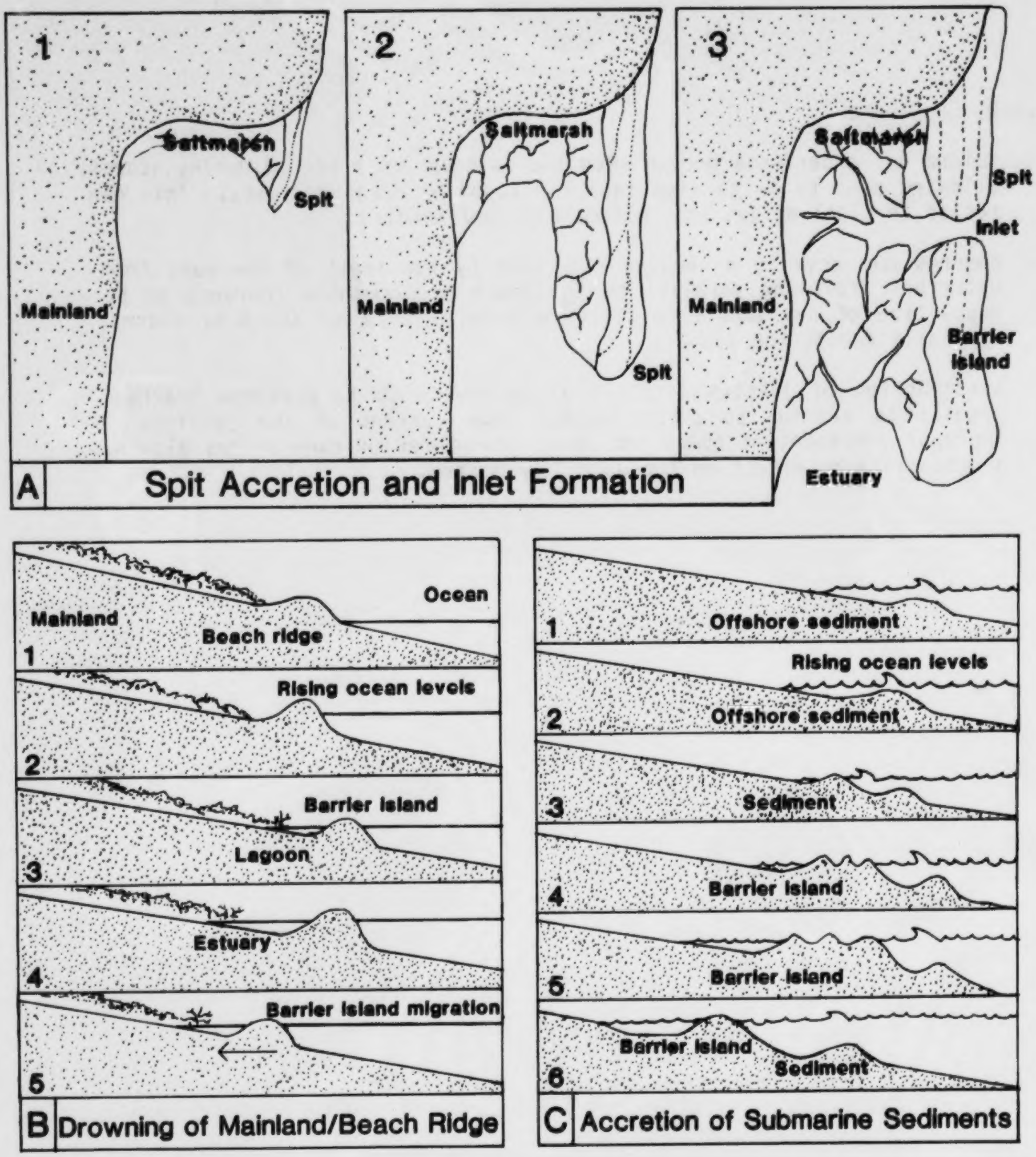

1
Saltmarsh
Spit
Mainland
2
Saltmarsh
Mainland
Spit
3
Saltmarsh
Spit
Inlet
Mainland
Barrier Island
Estuary
A Spit Accretion and Inlet Formation
Ocean
Mainland
Beach ridge
1
Rising ocean levels
2
Barrier island
Lagoon
3
Estuary
4
Barrier island migration
5
B Drowning of Mainland/Beach Ridge
1
Offshore sediment
Rising ocean levels
2
Offshore sediment
3
Sediment
4
Barrier island
5
Barrier island
Barrier island
Sediment
6
C Accretion of Submarine Sediments

Figure 2.3.2 Formation of Barrier Islands
Sources: Leatherman, 1979; Godfrey & Godfrey, 1976; Dolan, et. al., 1980.

2.3.2 Continued

island may experience growth when the islands are breached during storms, allowing sand to be carried into the sound by ocean currents. This can result in tidal deltas and, ultimately, new land.

- Beaches may grow in a seaward direction by the input of new sand from upcurrent traveling parallel to the beach by longshore currents or by deposition of new sand from offshore being brought on shore by storms, typically during the summer.

- Construction of jetties (groins) along the coast to preserve beaches results in erosion to other beaches down current of the jetties. Improper placement of homes and other structures on dune ridges also has a destabilizing effect on the sand dune system.

SOILS ON THE BARRIER ISLANDS ARE PRINCIPALLY GRANULAR IN STRUCTURE

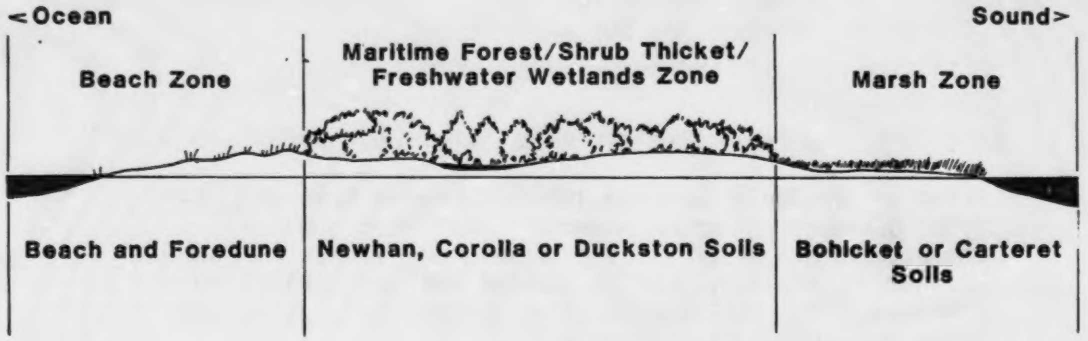
Soils on the North Carolina barrier islands have developed from Quaternary marine deposits and have physical characteristics which range from deep and excessively well drained to shallow, poorly drained and are subject to flooding. The Soil Conservation Service has mapped and rated the soils of the study area.

The present day barrier island soils developed from unconsolidated Quaternary marine deposits or parent materials and are relatively young compared to soils found on the mainland. Soils in the dune and grassland areas are coarse textured and, for the most part, granular in structure. Consequently, these soils are well drained or excessively drained. Finer textured soils, such as clayey soils, are found in the low lying sectors on the islands, referred to as the marsh zone. Finer textured soils are shallow and contain a horizon consisting mostly of decaying organic materials and seasonally high water tables.

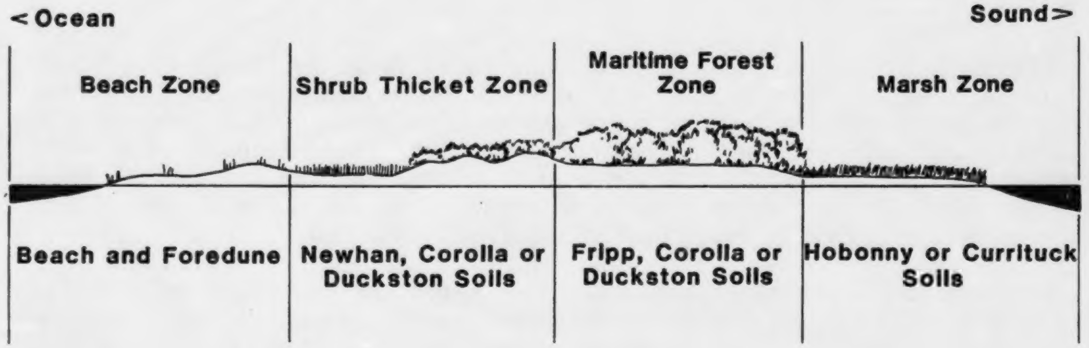
The USDA Soil Survey has a taxonomic classification system to describe the major characteristics of soils. Additionally, the effects of soil characteristics on agriculture, construction, waste disposal, recreation, water management and other uses have been categorized to identify the most suitable uses.

The soil survey for the North Carolina Outer Banks published by the USDA SCS contains maps of individual soil units. These maps were prepared using field surveys, soil samples and correlations with nearby soils. The maps are inscribed on individual aerial photographs to enable location of the soil types. These mapping units are useful for determining the suitability of an area for the construction of homes and septic tank absorption fields. Site specific evaluations are required for actual construction.

Figure 2.3.3 depicts the principal soil types and vegetation with respect to topographic zones on the North Carolina barrier islands. Table 2.3.3.a lists some of the principal physical characteristics affecting the suitability of both major and minor soils types for selected land uses. Table 2.3.3.a also presents a potential rating of soils in a natural condition for septic tank absorption fields. These ratings do not necessarily indicate suitability; some limiting soil properties may not absolutely restrict certain uses although they may limit soil performance. Many limitations can be easily corrected, while others cannot. Table 2.3.3.b depicts the USDA-SCS ratings for septic tank absorption field limitations.


<Ocean
Sound>
Beach Zone
Maritime Forest/Shrub Thicket/ Freshwater Wetlands Zone
Marsh Zone
Beach and Foredune
Newhan, Corolla or Duckston Soils
Bohicket or Carteret Soils

SOUTHERN SECTION


<Ocean
Sound>
Beach Zone
Shrub Thicket Zone
Maritime Forest Zone
Marsh Zone
Beach and Foredune
Newhan, Corolla or Duckston Soils
Fripp, Corolla or Duckston Soils
Hobonny or Currituck Soils

NORTHERN SECTION

Figure 2.3.3 Characteristic Soil Types of the North Carolina Barrier Islands.
Source: U.S. Department of Agriculture Soil Conservation Service.

Table 2.3.3.a. Soil Series and Characteristics for North Carolina Barrier Islands.

Soil Series	Flooding	Depth to Seasonal High Water Table	Permeability (in/hr)
Beach	frequent (monthly)	1.0 - 3.0'	rapid, 6.3
Leon fine sand	some surface ponding	0.0 - 3.0'	rapid, 6.3
Beach-Foredune Assoc.	frequent-rare	Beach 0.0-3.0' Foredunes 6.0'	rapid, 6.3
Bohicket, low	frequent (daily)	0 - 3.0'	slow 0.06"/hr.
Tidal flats	frequent (monthly)	0 - 3.0'	rapid 6.3"/hr.
Carteret, low	frequent (daily)	0.0 - 3.0'	rapid 6.3"/hr.
Corolla fine sand	rare to common - storm tides	1.5 - 3.0'	very rapid 20"/hr.
Corolla fine sand forested	rare - high storm tides	1.5 to 3.0'	very rapid 20"/hr.
Dredge spoil	rare - storm tides	3.0'	rapid 6.3"/nr.
Hobonny soils	frequent (monthly)	0 - 2.0'	moderate 0.63-2.0"/hr.
Duckston fine sand,	rare to common-storm tides		very rapid 20"/hr.
Duckston fine sand, forested	rare to common-storm tides	1.0 - 2.0'	very rapid 20"/hr.
Duneland	none	6.0'	very rapid 20"/nr.
Fripp fine sand	rare - storm tides	6.0'	rapid 6.3"/hr.
Levy	frequent (monthly)	0.0 - 2.0'	slow 0.06 - 0.2"/hr.
Madeland	rare - storm tides	3.0'	rapid 6.3"/hr.
Carteret, high	frequent (monthly)	1.0 - 3.0'	rapid 6.3"/nr.
Carteret	frequent (monthly)	0.0 - 3.0'	rapid 6.3"/hr.
Currituck	frequent (monthly)	0.0 - 3.0'	rapid 6.3"/hr.
Newhan fine sand	none	6.0'	very rapid 20"/hr.
Duneland-Newhan Complex		6.0'	very rapid, impervious material urban
Wando fine sand	none	6.0'	very rapid 20"/hr.
Canaby	surface ponding	0.0 - 1.0'	rapid 6.3"/hr.

Table 2.3.3.a. Continued

Soil Series	Flooding	Depth to Seasonal High Water Table	Permeability
Echaw fine sand	none	2.5 - 5.0'	rapid 6.3"/hr.
Kureb fine sand	none	6.0'	rapid 6.3"/hr.
Currituck, high	frequent (monthly)	0.0 - 2.0'	rapid 6.3"/hr.
Bohicket, high	frequent (daily)	0.0 - 3.0'	slow 0.06"/hr.

Source: USDA Soil Conservation Service. 1977.

Table 2.3.3.b. Potential Rating of Soils for Septic Tank Absorption Fields

Soil Series Name	Limitations for Sanitary Facilities
Beach	very severe - flooding
Leon fine sand	very severe - high water table
Beach - Foredune Assoc.	very severe - flooding
Bohicket, low	very severe - flooding - wet
Tidal flats	very severe - flooding - wet
Carteret, low	very severe - wet
Corolla fine sand	severe - wet
Corolla fine sand, forested	severe - wet
Dredge Spoil	severe
Hobonny	severe - flooding - wet
Duckston fine sand	severe - wet
Duckston fine sand, forested	severe - wet
Duneland	severe - unstable due to blowing sand
Fripp fine sand	slight
Levy	very severe - flooding - wet
Madeland	severe
Carteret, high	very severe - flooding - wet
Carteret	very severe - flooding - wet
Currituck	very severe - flooding - wet
Newhan fine sand	slight
Duneland-Newhan Complex	sandy and droughty, well-drained
Wando fine sand	slight
Conaby	very severe - floods, wet
Echaw fine sand	severe - wet
Kureb fine sand	slight
Currituck, high	very severe, floods, wet
Bohicket, high	

Source: USDA Soil Conservation Service. 1977.

OFFSHORE TOPOGRAPHY IS IRREGULAR WITH SMOOTH BOTTOMS, RIDGES, TERRACES AND REEFS INTERSPERSED TO THE SHELF BREAK

The continental shelf ranges from approximately 33 Km in width at Cape Hatteras to 110 Km in width at Cape Fear. In general, the topography is irregular, with numerous ridges and terraces aligned at various angles to the coastline. Bottom areas are dotted with patch reefs of coral and limestone outcroppings in both nearshore and offshore areas.

The seafloor topography is varied along the coast of North Carolina and ranges from 33 km (19.8 mi) at Cape Hatteras to approximately 110 km (66 mi) in the Long Bay region near the North Carolina/South Carolina border (U.S. Dept. of Interior 1978, 1980). The areas north of Cape Hatteras are represented by uniform sediments and a steep slope to the shelf break. The areas south of Cape Hatteras have numerous patch reefs, hard bottom areas, and sand ridges and terraces aligned at right angles to the beaches (Uchupi 1967).

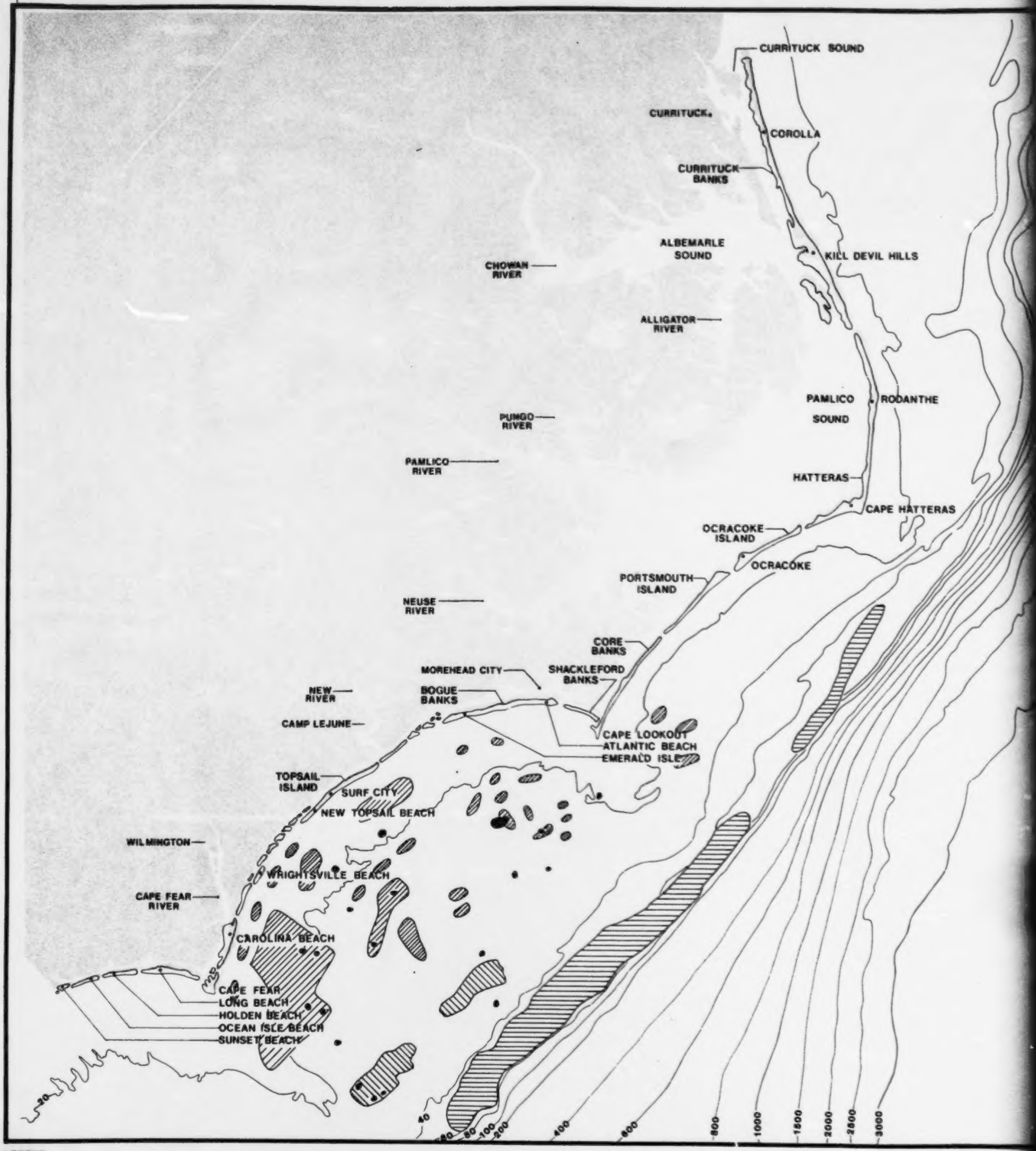
The Atlantic continental shelf area can be separated into the four marine bays that are located along the coast. The Hatteras Embayment extends from the shelf area of Virginia to the Cape Hatteras point. The general topography of the southern portion of the Hatteras Embayment is characterized by a fairly narrow and steep shelf zone of mostly uniform soft sediments (Newton et al. 1971). While this area is represented by smooth bottoms with a steep slope to the shelf break, there is evidence of sand ridges aligned at right angles to the shoreline (Hollister 1973). The second topographic marine bay is Raleigh Bay from Cape Hatteras to Cape Lookout. Raleigh Bay can be termed a transition zone from the relatively narrow, steep and totally sandy-sediment floored Hatteras Embayment to the shallow, wide and rock-dominated shelf of Onslow Bay.

The other two bays, Onslow Bay and Long Bay, are similar in many topographic features. Onslow Bay from Cape Lookout to Cape Fear is generally characterized by a shallow and wide shelf zone dominated by patch reefs and rock outcroppings. These rock outcrops are irregularly spaced on the shelf and extend southward to Florida. This area also has more numerous sand ridges and terraces than the bays further north (Hollister 1973). Long Bay from Cape Fear to Cape Romain, South Carolina is similar to Onslow Bay in having a shallow and wide shelf zone to the shelf break. Only the northern most part of this bay is located in the study area. While there are no coral patch reefs in this bay, the hard bottom reefs can be found offshore (U.S. Dept. of Interior 1978, 1980).

The major topographic features are presented in Figure 2.3.4 and include depth contours; inner, middle and outer banks; and patch coral reefs. The inner banks have low relief (height from seafloor 3-5 m) but the rocky outcrops support large numbers of sessile organisms (see Section 2.2.3.3 for

2.3.4 Continued

more information on marine communities associated with reefs). These areas are known as hard-banks or live bottoms and are distributed discontinuously from Onslow Bay southward into the Georgia Embayment (Figure 2.3.4). The middle and outer banks also extend from the southern portion of Raleigh Bay through Onslow Bay onto the Georgia Embayment. The relief is generally greater as distance from shore increases. Other than these reefs, seafloor topography is dominated by numerous sand ridges and terraces (Hollister 1973). Information on the shelf geology and sediments can be found in Sections 2.3.5.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CHOWAN RIVER
ALLIGATOR RIVER
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RODANTHE
PUNGO RIVER
PAMLICO RIVER
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CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
CAPE FEAR
LONG BEACH
HOLDEN BEACH
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20
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LEGEND

- ■ Patch Reefs
- ▨ Inner Banks
- ▧ Middle Banks
- ☰ Outer Banks

Figure 2.3.4
Topographic features of the marine seafloor off the coast of North Carolina (Sources: U.S. Dept. of Interior 1978, 1980; Coastal Plains Region Commission 1979; MacIntyre 1970; Hollister 1973).

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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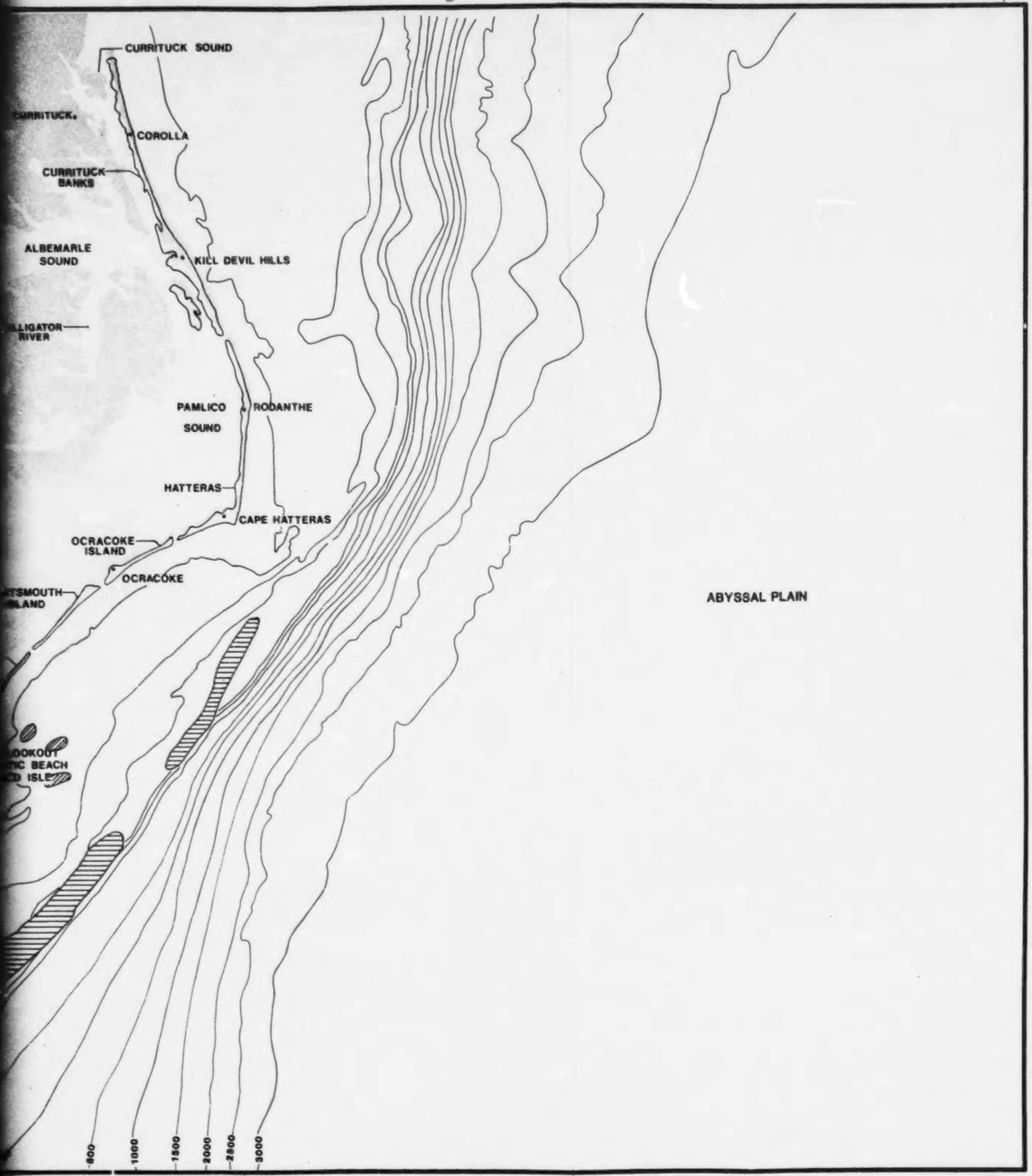
GANNETT FLEMING CORDDRY AND CARPENTER, INC.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40

(Sources: U.S. Dept. of
Hollister 1973).

100a

2.0 DESCRIPTION OF THE NATURAL ENVIRONMENT
2.3 Topography, Geology & Soils
2.3.5 Marine Geology

CONTINENTAL SHELF GEOLOGY IS DOMINATED BY HOLOCENE SANDS AND BARRIER ISLANDS

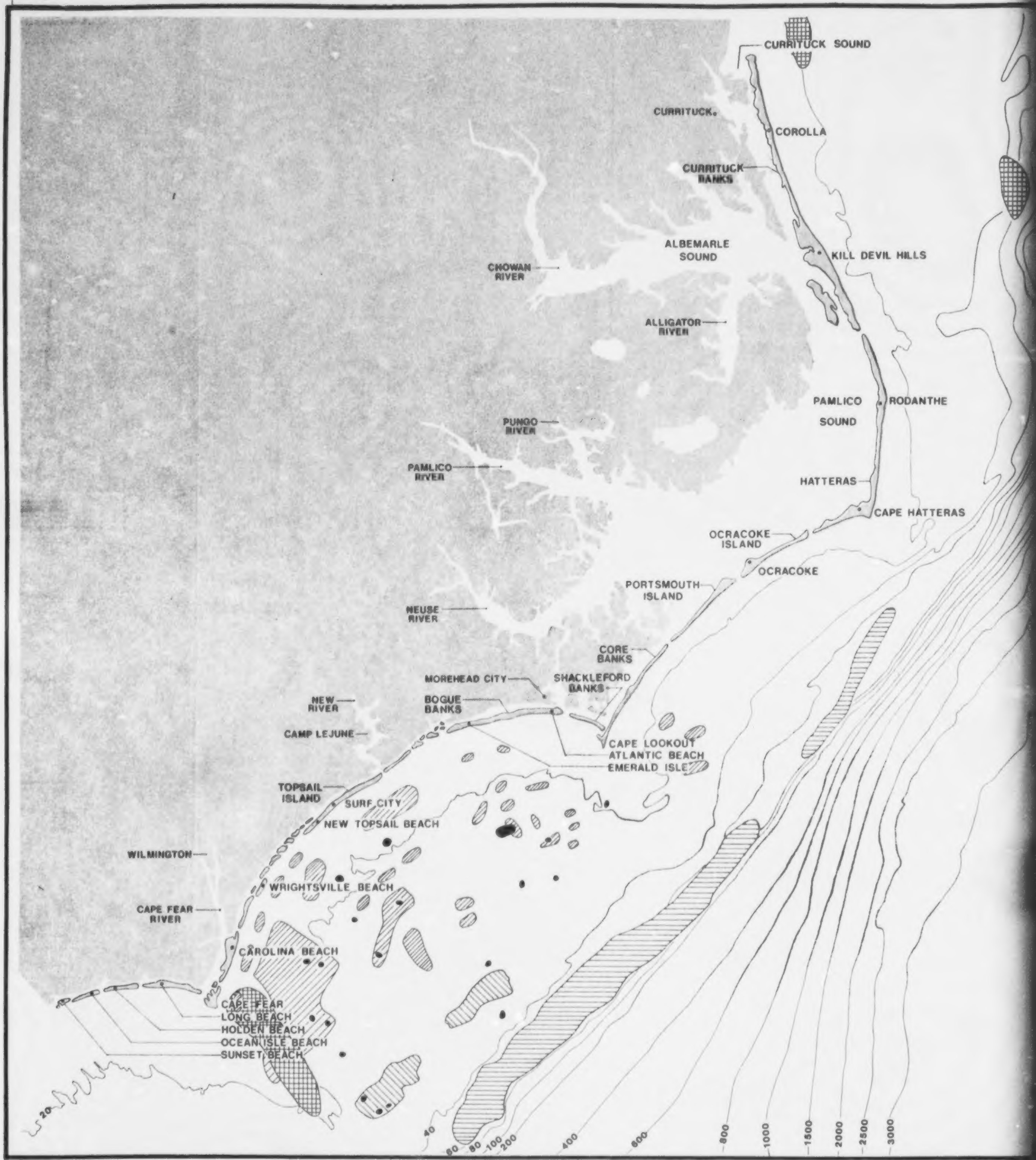
The seafloor geology is dominated by various textures of sandy sediment. The top surface is dominated by Holocene sands with areas of Miocene/Pliocene marls and Pleistocene sands exposed by the current and circulation patterns. The shelf area is a dynamic system under constant change.

The geology of the continental shelf is somewhat complex and a number of theories have been proposed concerning this subject. Many of these theories also address the formation and early history of barrier islands. It is thought that the barrier islands were further out along the shelf during the Pleistocene Epoch (ca. 1 million years ago) and may have been located at the shelf break (Moslow and Heron 1979, 1981). The formation of deltas from river transport during the Pleistocene Epoch. which was characterized by reduced sea levels, supports this theory. With the rising sea levels during recent times (Holocene Epoch ca. 18,000 years ago), these islands have retreated towards the mainland. The offshore ridges and terraces found at the present time are thought to be relict barrier islands and are covered with thinner layers of Holocene sediments as the shelf break is reached (Hoyt and Henry 1971, Swift et al. 1972, Field and Duane 1976).

The location of the inner, middle, and outer banks as well as patch coral reefs are shown in Figures 2.3.4 and 2.3.5. The inner banks and middle banks have probably originated from Pliocene deposits as well as Miocene mud marls and Pleistocene sands (Hunt 1974). Patch reefs of coral heads are also found in the middle and inner banks and are thought to be composed of projections of Miocene marls (Dillon et al. 1975). The outer banks are interpreted as Pleistocene algal reefs (Menzies et al. 1966) and exist as a series of ridges and terraces which extend along the shelf break from Cape Hatteras to southern Florida (Uchupi and Tagg 1966, Uchupi 1967, Uchupi and Emery 1968, Zatudzki and Uchupi 1968). These reefs apparently formed during the low sea level periods of the Pleistocene Epoch (Fairbridge 1960). All of the reefs and hard banks are maintained by the current and circulation patterns. These same patterns have caused portions of the underlying Pliocene and Miocene sediments (ca. 25 million years ago) and Pleistocene sediments to be exposed and colonized (see Section 2.2.3.3 on reef communities).

The marine seafloor of the continental shelf is dominated by limestone overlaid with a thin veneer of sand. These shelf sands are Holocene sediments which overlay Pleistocene sands (Moslow and Heron 1978, 1979, Swift et al. 1972, Pierce and Colquhoun 1970, Moslow 1977). This layer of Holocene sands is thickest on the barrier islands and becomes thinner out along the shelf to the continental slope. Early Tertiary sediments occur along the continental slope. These include sediments of the Paleocene (ca. 70 million years ago), Eocene (ca. 60 million years ago) and Oligocene (ca. 40 million years ago) (Uchupi 1967).

If the Quaternary sediments (Holocene and Pleistocene) were removed,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CAPE FEAR
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OCEAN ISLE BEACH
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LEGEND

- ■ Patch Reefs
- ▨ Inner Banks
- ▧ Middle Banks
- ▤ Outer Banks
- ▦ Gravelly Sands

Figure 2.3.5

Offshore sediment features of the coastal region of North Carolina (Sources: U.S. Dept. of Interior 1978, 1980; Coastal Plains Region Commission 1979; Hollister 1973; Newton et al. 1971).

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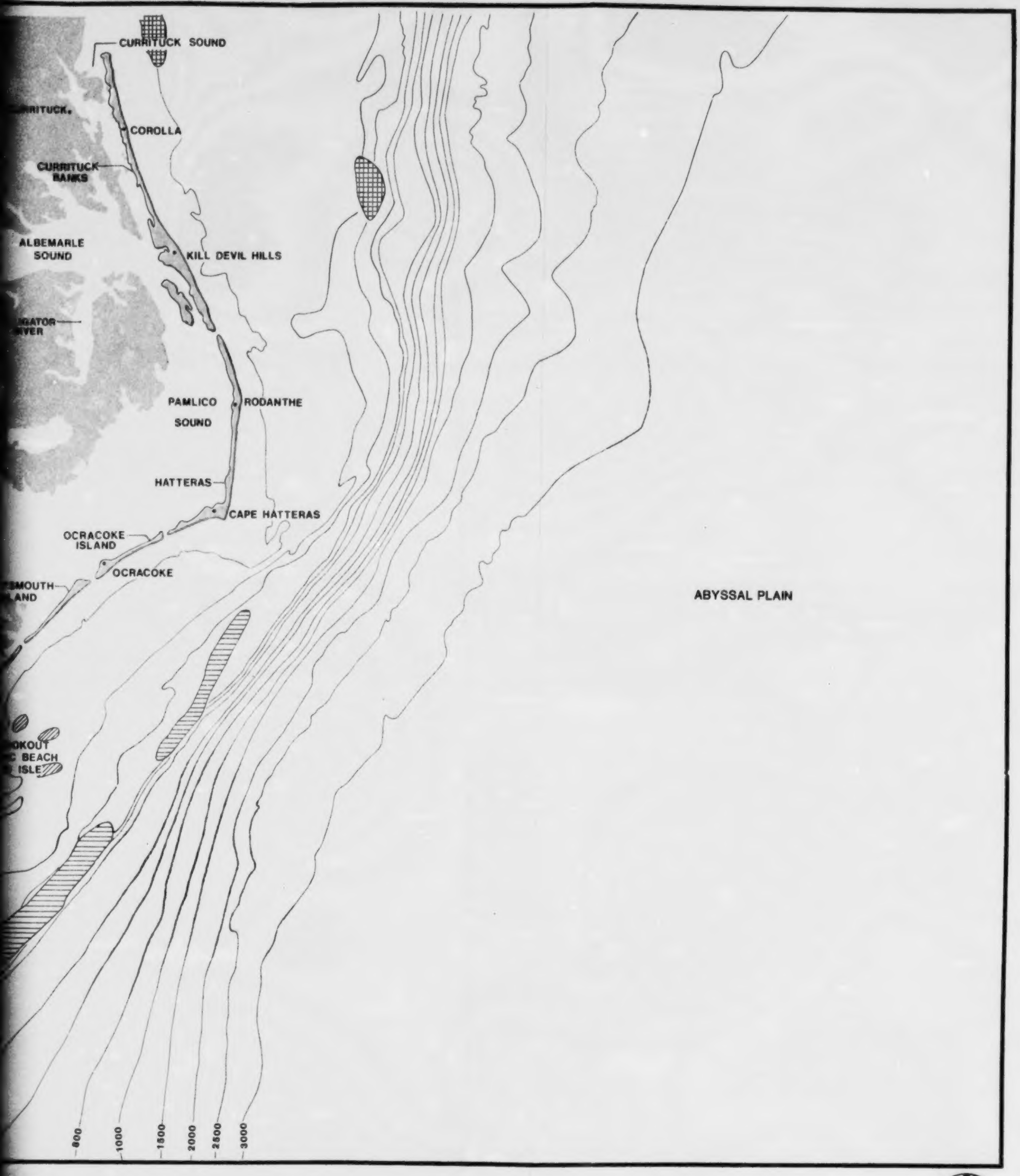
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SCALE IN MILES
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U.S. Dept. of Interior
l. 1971).

2.3.5 Continued

most of the shelf area would be covered with Pleiocene and Miocene sediments. This is confirmed by dating techniques from the hard banks reefs (Dillon et al. 1975, Uchupi 1967). The Holocene shelf sands are arranged in a series of shoals at right angles to the beach. These shoals are also formed and propagated by current and circulation patterns (Hollister 1973). Even though sea level rise has somewhat slowed in Holocene times, this marine shelf and barrier island system is still undergoing changes from longshore and mainland drift, washovers from storm events and inlet migration (see Section 2.3.7) (Moslow and Heron 1979, 1981).

Hollister (1973) found that the sediments in the North Carolina area were dominated by unimodal, well sorted sands which have a symmetrical grain-size distribution curve. Finer sands are found near the barrier islands with coarser sands found near the shelf break. The shelf sands containing appreciable amounts of calcium carbonate are generally found south of Cape Hatteras extending into the Georgia Embayment. The sands of the Hatteras Embayment are composed of quartz and feldspar. Rock-dredge samples from the hard banks of this region are represented by algal limestone, quartz-rich calcarenite, calcareous quartz sandstone, and shell hash (Hollister 1973). These samples were taken from the middle and outer banks. The main difference between the sediments between the area north of Cape Hatteras and areas south is that the non-carbonate fraction is significantly higher in the sandstones south of Cape Hatteras. Figure 2.3.5 shows that all sediment areas that are not illustrated as reefs or hard banks are sandy bottoms. This is a broad category, with a large variety of sediment types. Newton et al. (1971) studied the types of sediment found along this coast and complete mapping can be found in this reference.

Also of importance to the study of shelf marine deposits is the distribution of marine minerals in this area. Newton et al. (1971) and Lutennauer and Pilkey (1967) studied the distribution and abundance of heavy minerals and phosphorite grains along this coast. Heavy minerals are found along the beaches in northern Onslow Bay and extending into Raleigh Bay and along the shelf out to the shelf break. A large area of phosphorite grains is located from Bogue Banks to Cape Fear, with highest concentrations found off Cape Fear. These phosphate concentrations are of economic importance to the area. These minerals originate from the shelf area offshore where they were uncovered and transported by the currents, waves, and tides. Little of this material is transported by the rivers of this area (Newton et al. 1971, Lutennauer and Pilkey 1967).

EROSION/ACCRETION IS CRITICAL TO BARRIER ISLAND FORMATION

Erosion and accretion are natural processes on the barrier islands of North Carolina. Some of the factors that control erosion/accretion include rising sea levels, longshore drift, winds, waves, tides, offshore topography, geometry and orientation of shoreline, and storm events. Inlet formation and migration, overwash fans and island migration are the major results of this process.

The erosion and accretion of sediments is a natural and ongoing process dating back to the original formation of these islands during the Pleistocene Epoch. During recent geologic times the barrier islands began migrating towards the mainland. According to most authorities, the landward migration of islands is ultimately caused by the worldwide rising of ocean levels (Godfrey and Godfrey 1976; Dolan et al. 1973, 1980; Pilkey et al. 1978; Leatherman 1979). According to recent estimates, sea levels along the North Carolina coast are rising at a rate of about one foot per century. Although this figure may seem insignificant, comparisons of barrier island locations from maps and aerial photos indicate that the long-term landward movement of some barrier islands may be considerable (see Figure 2.3.6). The primary means by which landward migration occurs is from storm overwashes and inlet formation, but longshore drift may also be involved. Long-term measurements indicate that shorelines are generally retreating westward along the North Carolina coast at a rate of three to five feet per year (Pilkey et al. 1978). It is important to emphasize that although shoreline retreat is often referred to as erosion, this process is more typically one of rearrangement. For instance, lands are continually shifted to new locations but are generally not lost from the barrier island system as a whole.

Other factors that cause erosion/accretion include offshore topography, circulation patterns, waves, tides, winds, nature of shoreline orientation and geometry, and storm events. The process of erosion/accretion is one of the most important aspects of barrier island management, affecting inlet propagation and migration, overwash zones and beach and island migration.

Throughout history, the inlets between islands have undergone constant change and modification (Baker 1977, Priddy and Carraway 1978). (See Figure 2.4.1.c for locations of inlet hazard zones). The time scale for these changes can be centuries or less than a year (Baker 1977, Priddy and Carraway 1978). When storms strike the North Carolina coast, opening or closings of inlets can occur overnight, largely a result of water pressure that builds up on the sound side of the islands. Most of these inlets are constantly changing their positions but seem to fluctuate in the region of their ancestral inlets (Pierce 1970, Baker 1977). In general, the movement of inlets is from north to south following the current patterns (Hollister 1973, El-Ashry and Wanless 1968).

2.3.6 Continued

Related to the inlet propagation, formation, and migration process is the process of washover fans (See Figure 2.6.3.b for example of historic shoreline changes). (See Figures 2.4.1.a and 2.4.1.b regarding inlet and washover fan relationships). Washover fans are formed in low-lying areas by the rising storm surge waves. The storm surge piles up along the coast and the general movement is from the beaches into the sounds. Washover fans provide sediments necessary to allow for propagation of salt marsh areas on the sound side of these islands.

Sand sharing is a general term referring to the overall balance or equilibrium of lands maintained on barrier islands. In simple terms, land (or sand) that is lost at one place is regained or redistributed elsewhere. Vegetational cover is essential to the proper functioning of the sand sharing system: natural dune and beach vegetation is dense enough to partially stabilize the sandy island soils, but is sparse enough to allow redistribution according to changing environmental conditions. For instance, sea oats and other salt spray tolerant plants help to stabilize primary dunes from the daily erosive forces of winds and waves but will allow the sandy soils to rearrange when exposed to strong storm winds and waves. Figure 2.6.3.c shows in profile how the sand sharing system works on beaches and ocean-front dunes in response to storm conditions. On a larger scale, the sand sharing concept can also be applied to the previously discussed equilibriums associated with barrier island migration and inlet dynamics.

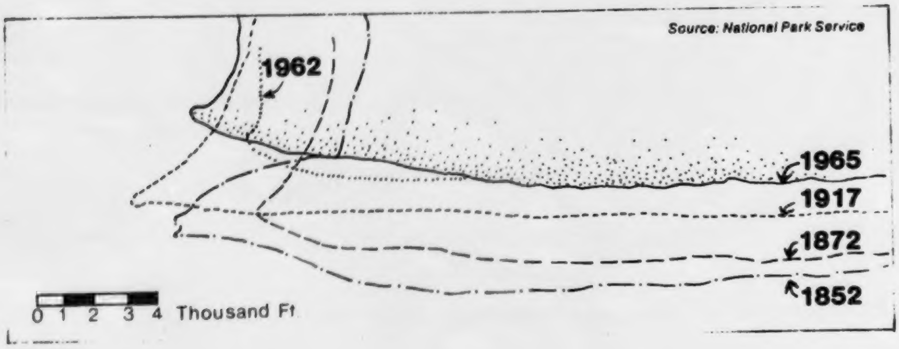
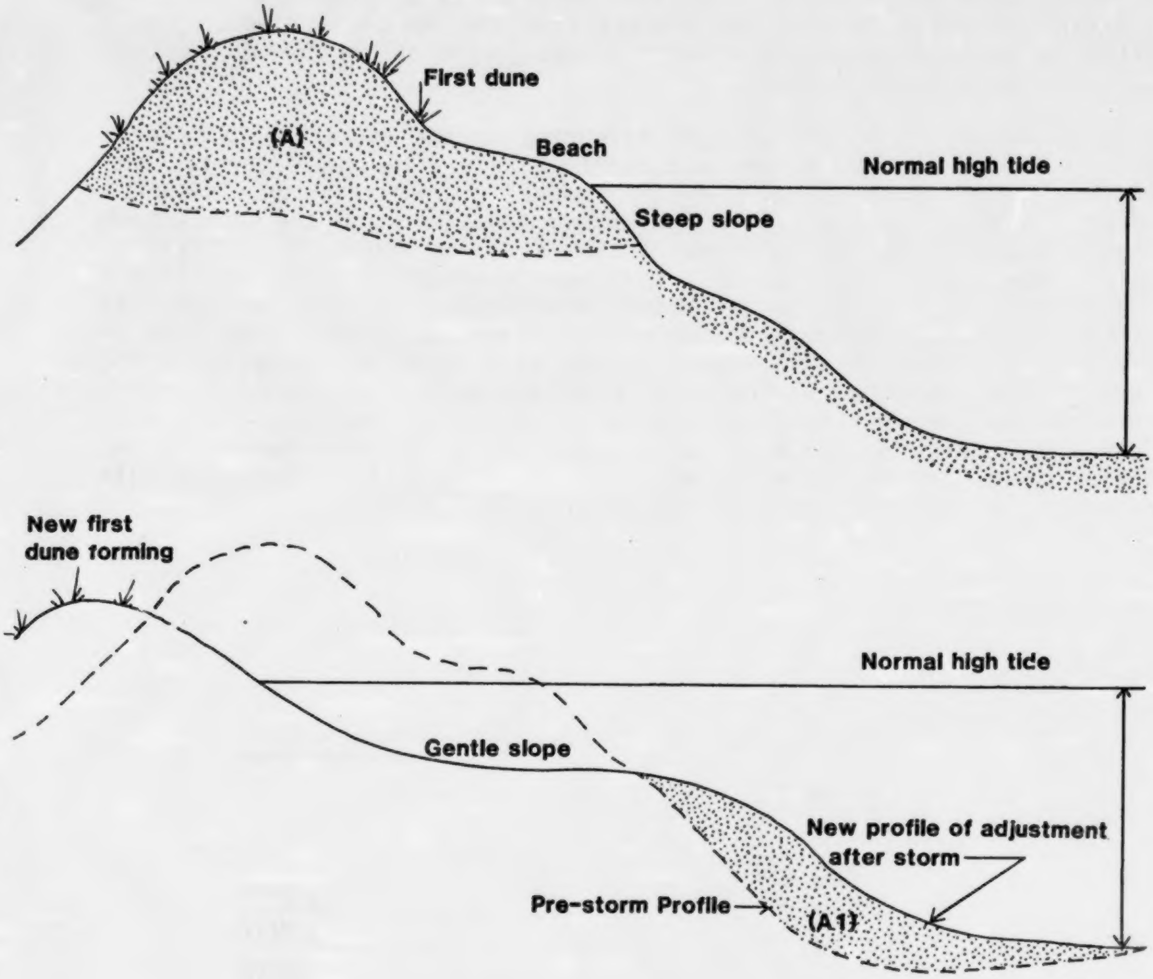


Figure 2.3.6.a Historic shoreline changes at Cape Hatteras 1852-1965.

Source: National Park Service In Dolan et al. 1973.


First dune
(A)
Beach
Normal high tide
Steep slope
New first dune forming
Normal high tide
Gentle slope
New profile of adjustment after storm
Pre-storm Profile
(A1)

(Shaded area A1 is approximately equal to shaded area A.)

Figure 2.3.6.b Beach Flattening in Response to a Storm
Source: Adapted from Pilkey, et. al., 1978.

A NUMBER OF ENVIRONMENTALLY SENSITIVE AREAS OCCUR ON THE BARRIER ISLANDS

Sensitive areas are environmental features which warrant particular consideration for qualities such as uniqueness, rarity, hazardous conditions, high ecological value, and low tolerance to disturbance. Sensitive areas which are especially important to this study include: ocean hazard zones, biologically productive coastal waters, wetlands, wildlife nesting areas, maritime forests, designated natural areas and significant historic/archaeological sites.

A primary issue considered by this study is the problem of existing or future water pollution impacting the environment of the study area. Complicating this issue is the possibility of induced development on barrier islands resulting from the extension of wastewater treatment services to these areas. Barrier islands are sensitive to pollution and/or development for a number of reasons: vulnerability to storms with their associated high winds and floodwaters; continual erosion and accretion processes along island shorelines; and the presence of other sensitive features such as wetlands, protected species habitats and historic sites. Additionally, barrier islands perform an important protective function by shielding estuaries and mainland shores from the effects of storm events and normal erosional processes.

A number of environmentally sensitive features occur on the barrier islands of North Carolina. Detailed discussions of such sensitive areas are presented with regard to ocean hazard zones (Section 2.4.1), productive coastal waters (Section 2.4.2), wetlands (Section 2.4.3), wildlife nesting areas (Section 2.4.4), maritime forests (Section 2.4.5), and natural and cultural resource areas (Section 2.4.6). Historical and archeological resources are also discussed in Section 3.7. Each area is assessed in terms of qualities such as rarity, hazardous conditions, high ecological value and tolerance to disturbance.

OCEAN HAZARD ZONES ARE UNSUITABLE FOR DEVELOPMENT

The barrier islands contain a number of hazard zones which are unsuitable for development. Environmental factors and processes which create these hazards include winds, waves, flooding and unstable soils. Storms magnify the effects of these factors. Sensitive areas which are considered hazardous for development include coastal dune systems, overwash zones, inlets and floodplains.

Barrier islands are exposed to a number of potentially hazardous environmental factors and erosional processes including winds, wave action, flooding and unstable soils. Although such factors are continually present in the coastal zone, harmful effects are significantly intensified during storm events. Certain features which are particularly vulnerable to such hazards include coastal dune systems, overwash zones, inlets and floodplains.

Coastal dune systems include beaches and the ocean-front dunefields. A dynamic stability exists in this zone, whereby sands are continually transferred by winds and wave action, while the overall system remains in equilibrium. Erosion may occur at specific sites, but it is generally balanced by accretion at other sites, and ultimately there is no net loss within the entire coastal dune system (Godfrey and Godfrey 1976). Proper management and use of the coastal dune system necessitates an understanding that change is natural and inevitable within these areas (Dolan et al. 1973, Godfrey and Godfrey 1974).

Because coastal beaches and dunefields provide a buffer zone between the ocean and terrestrial/freshwater/estuarine communities, this system is especially critical to the barrier island ecosystem and vulnerable to human disturbances. Man-induced factors which may degrade the coastal dune system include removal or trampling of dunefield vegetation, leveling of dunes, dune-stabilization projects and over-grazing by domestic animals. Because of the ecological importance of the coastal dune system, the North Carolina Coastal Area Management Act regulates the development and use of this zone. More detailed discussions concerning the ecology of dunefields and the effects of altering these systems may be found in Sections 2.2.4.1 and 2.2.4.2.

Overwash zones are locations where ocean waters flood across barrier islands during storm conditions. Such zones usually occur at depressions or breaks in the ocean-front dunefields, which may be naturally formed or man-induced by excessive vehicle use, clearing of dune vegetation or leveling of dunes by developments. During overwashes, most vegetational cover is removed or buried by shifting sands and flooding waters. Nevertheless, natural recovery is usually rapid, and overwash sites are typically revegetated by grass flat communities within a couple of years time. (Godfrey and Godfrey 1976). However, the potential for repeated overwashes continues to exist while conducive topographic conditions remain, and such areas are accordingly hazardous for human developments.

2.4.1 Continued

On some developed barrier islands, artificial dunes have been formed in former overwash zones. Although these measures may help prevent future overwashes at these sites, such alterations may be ultimately detrimental to the barrier island ecosystem by causing more severe erosion of ocean beaches and intensified flooding on the sound side of barrier islands (see Figure 2.4.1.a). Moreover, overwash zones are important to the continued formation and maintenance of saltmarshes and other terrestrial communities, as shown in Figure 2.4.1.b. The locations of high-probability overwash zones on the barrier islands of North Carolina are shown in the Atlas.

Inlets function as channels for the changing levels of tidal waters and as outlets to the ocean for mainland stream water flows. Because of water currents and storms, the location of inlets can change significantly. During non-storm conditions, inlets commonly migrate in the prevailing direction of longshore currents. These openings often close up, leading to the formation of saltmarshes and other terrestrial communities (see Figure 2.4.1.b). In order to accommodate the increased volumes of water associated with storm events, existing inlets may enlarge or migrate, and new inlets may be formed in ocean overwash zones. Due to the highly dynamic structure of inlets and the flood susceptibility of nearby areas, inlet zones are hazardous for development. Because of these hazards, and the important navigational functions of inlet channels, developments occurring in or near inlets may be subject to regulation by the Army Corps of Engineers and the State of North Carolina (under jurisdiction of the Coastal Area Management Act). Figure 2.4.1.c shows the present location of inlet hazard zones on the barrier islands of North Carolina.

Floodplains encompass those areas that have a one percent chance of being flooded annually. Most of the lower elevation lands on the barrier islands occur within the 100-year floodplain, including many other features which are also considered sensitive areas: coastal dune systems (in part), overwash zones, inlet zones and wetlands. Most kinds of development are considered undesirable in floodplain areas unless certain precautions are taken, such as elevating structures above estimated storm surge levels. The extent of the 100-year floodplain on the barrier islands of North Carolina is delineated in the Atlas.

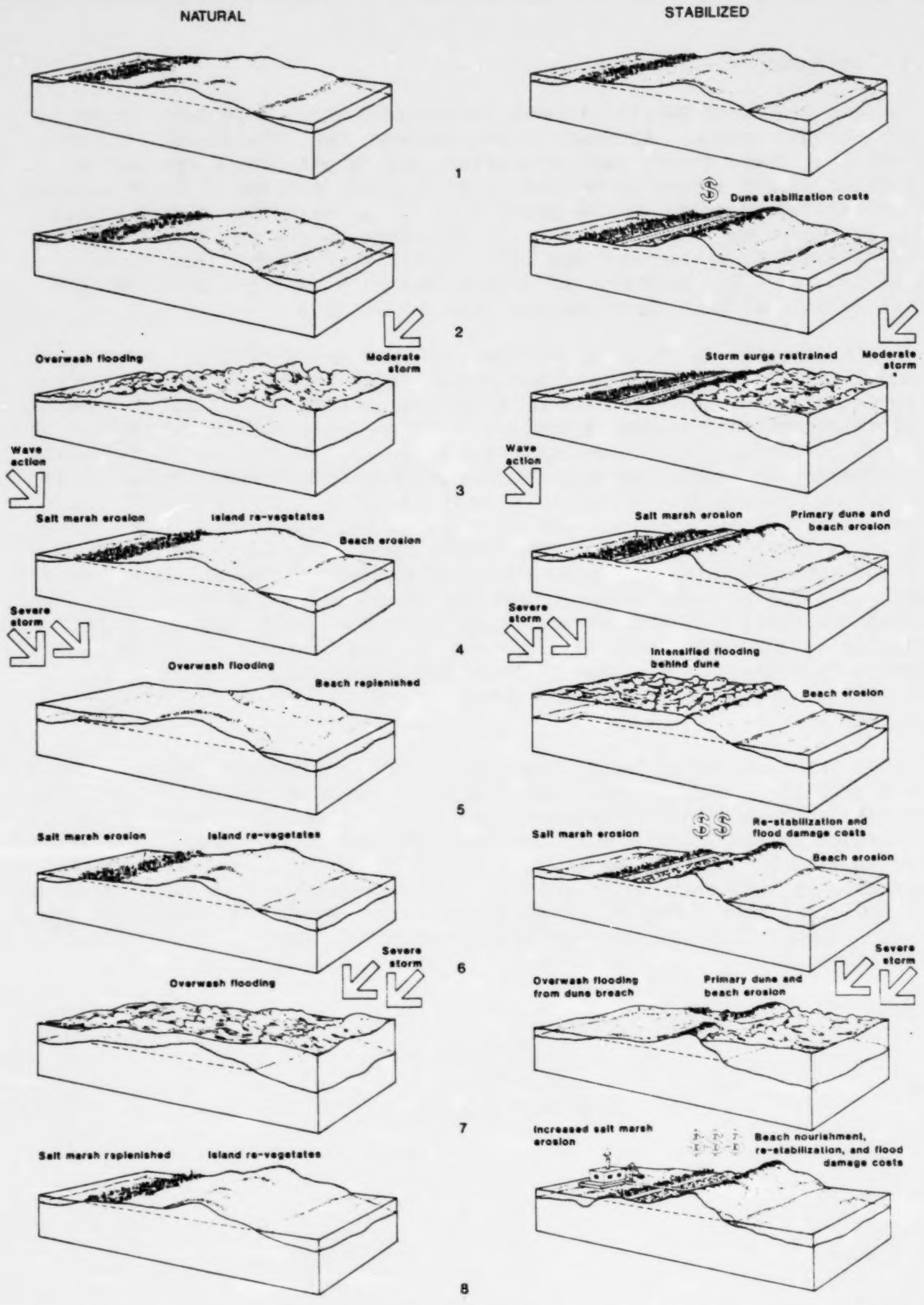

NATURAL
STABILIZED
1
Dune stabilization costs
2
Overwash flooding
Moderate storm
Storm surge restrained
Moderate storm
Wave action
3
Wave action
Salt marsh erosion
Island re-vegetates
Beach erosion
Salt marsh erosion
Primary dune and beach erosion
Severe storm
4
Severe storm
Overwash flooding
Beach replenished
Intensified flooding behind dune
Beach erosion
5
Re-stabilization and flood damage costs
Salt marsh erosion
Island re-vegetates
Salt marsh erosion
Beach erosion
Severe storm
6
Severe storm
Overwash flooding
Overwash flooding from dune breach
Primary dune and beach erosion
7
Increased salt marsh erosion
Beach nourishment, re-stabilization, and flood damage costs
Salt marsh replenished
Island re-vegetates
8

Figure 2.4.1.a Comparison of Natural and Stabilized Dune Systems in Response to Storms*
*Source: Godfrey and Godfrey (1976).

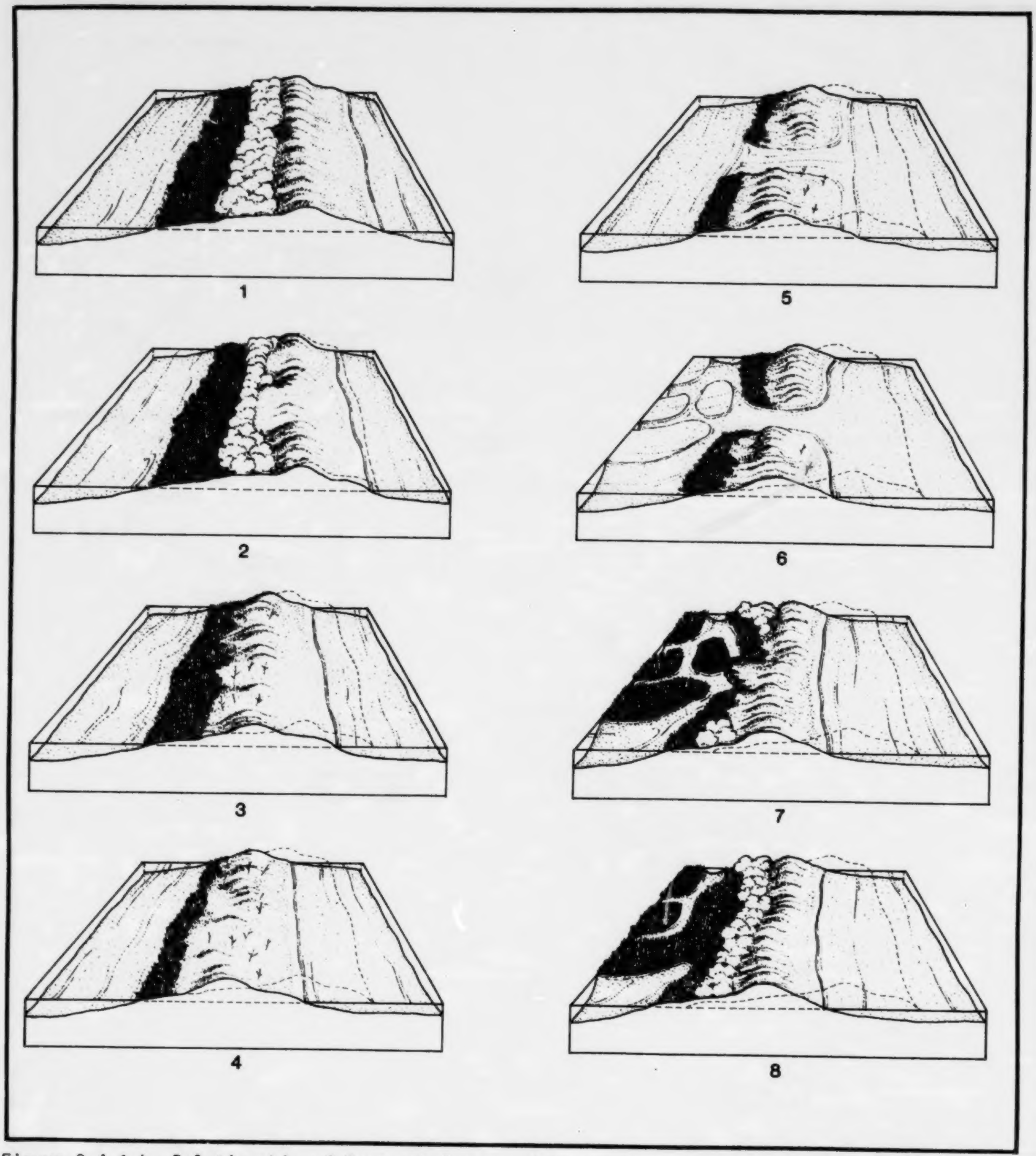
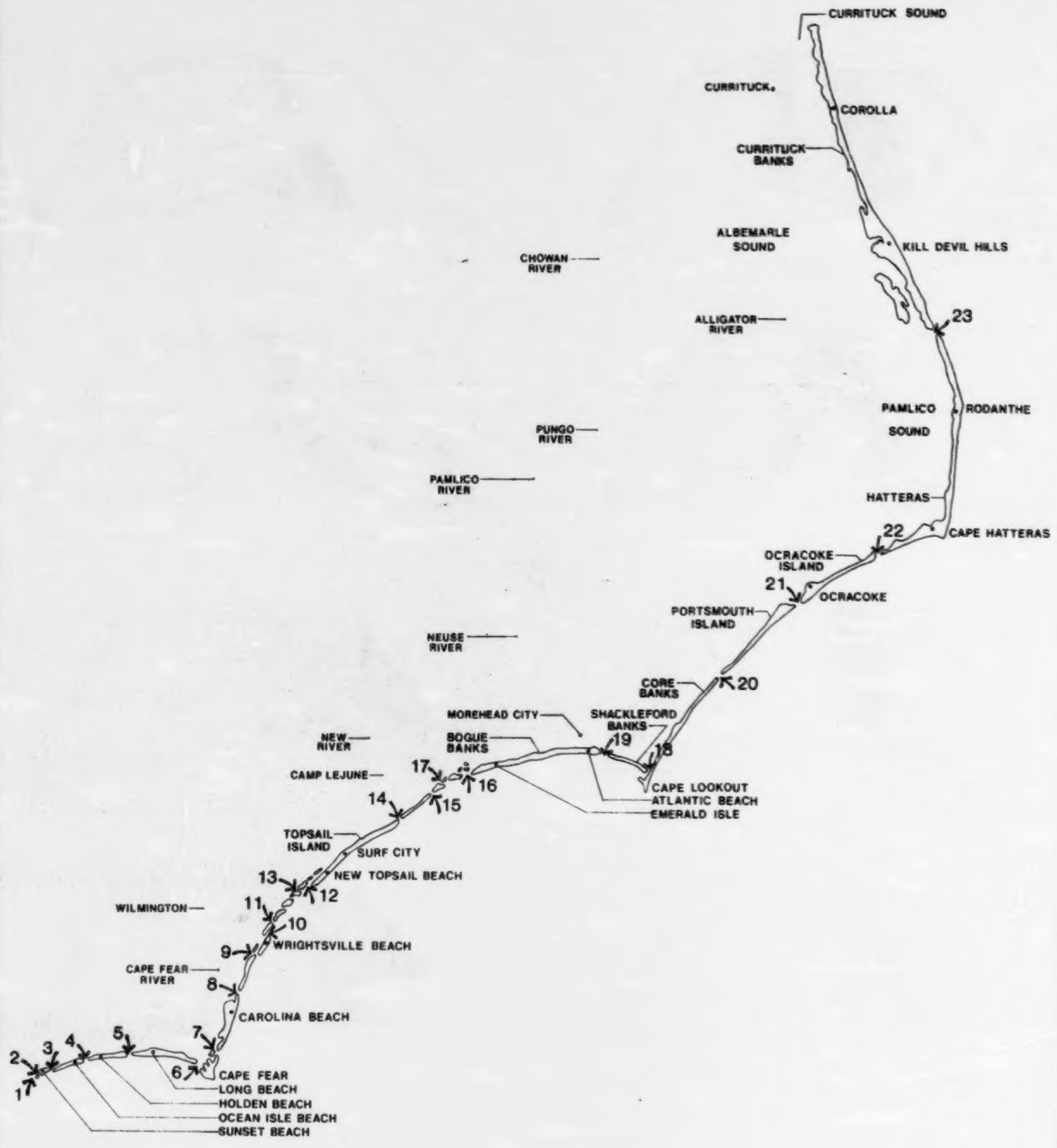


Figure 2.4.1.b Relationship of Overwash Areas and Inlets to Barrier Island Dynamics
Source: Godfrey and Godfrey (1976).


CURRITUCK SOUND
CURRITUCK.
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
KILL DEVIL HILLS
CHOWAN RIVER
ALLIGATOR RIVER
23
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
22
OCRACOKE ISLAND
21
OCRACOKE
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
20
MOREHEAD CITY
SHACKLEFORD BANKS
19
18
NEW RIVER
BOGUE BANKS
17
16
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
14
15
TOPSAIL ISLAND
SURF CITY
13
NEW TOPSAIL BEACH
12
WILMINGTON
11
10
9
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
8
CAROLINA BEACH
7
5
4
3
2
1
6
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH

Source: North Carolina Coastal Area Management Program,
Maps of Areas of Environmental Concern

LEGEND Figure 2.4.1.c. Inlet Hazard Zones.

1 Little River Inlet
2 Mad Inlet
3 Tubbs Inlet
4 Shallotte Inlet
5 Lockwood Folly Inlet
6 Cape Fear Inlet
7 New Inlet
8 Carolina Beach Inlet
9 Masonboro Inlet
10 Mason Inlet
11 Rich Inlet
12 New Topsail Inlet
13 Old Topsail Inlet
14 New River Inlet
15 Brown's Inlet
16 Bogue Inlet
17 Bear Inlet
18 Barden Inlet
19 Beaufort Inlet
20 Drum Inlet
21 Ocracoke Inlet
22 Hatteras Inlet
23 Oregon Inlet

Source: Priddy & Ca[illegible]ay (1978).

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

SCALE IN MILES
5 2.5 0 5 10 15 20 30 40

PRODUCTIVE COASTAL WATERS OCCUR IN ESTUARINE AND MARINE ZONES

The productive coastal waters in North Carolina include estuarine seagrass beds, estuarine oyster reefs, and marine hard bottom communities. Each of these systems is highly productive in terms of both shellfisheries and finfisheries. The abundance of food and nursery habitat make these areas important.

Productive coastal waters are considered sensitive areas because these systems produce a large number of shellfish and finfish. Many of these species are important to both local commercial and sportsfishing interests. These areas benefit from an abundance of food nutrients and serve as both nursery and breeding grounds for many species of fishes, crabs, shrimps, clams, scallops, and oysters.

The systems described below provide protection from predators for many of these species as well as serve to stabilize the sediment which protects the barrier island from erosion. While most of the ecological information on these high production zones can be found in Sections 2.2.2 and 2.2.3, the following discussion will present some of the basic information on these systems. All of the systems are widespread throughout estuarine areas behind the barrier islands as well as offshore in the marine area. These include the estuarine seagrass beds, estuarine oyster and clam beds and marine hard bottom zones.

Seagrass beds are widely distributed throughout North Carolina estuaries, but no mapping of these areas exists at this time. However, it is known that seagrass beds cover vast areas of Pamlico, Bogue, and Core Sounds. These areas provide a large food source as well as nursery and protected areas for many species. Some of the most important species in seagrass beds include bay scallops, soft shell clams, white shrimp, pink shrimp, blue crab, spot, atlantic croaker, seatrout, bluefish, and numerous other species. Seagrass beds are considered to be the most diverse of all estuarine subsystems. (See Section 2.2.2.3 for more information on seagrass beds.)

Estuarine oyster reef communities are based on the successive generations of oysters that have developed over the years. The oyster, itself, is of importance to the local shellfisheries. Because these organisms build reefs, many other fish and invertebrates are attracted to these areas (see Section 2.2.2.4 on oyster reefs). In addition, the soft sediment areas adjacent to oyster reefs often contain large numbers of hard clams. Both of these areas are mapped in Section 3.5.3 of this report.

In the offshore marine region of North Carolina, natural rock outcroppings occur in small patches near shore and become more abundant offshore. These reefs are fished extensively by sports and commercial fishermen. These reef areas are known to the fishermen as live bottoms, snapper banks, or

2.4.2 Continued

fishing banks. The dominant fish in these reefs include groupers, snappers and jacks. Because of the congregation of fish, some of the larger pellagic fishes such as spanish mackerel and cobia will also be found in these areas.

North Carolina marine waters have been the site of numerous shipwrecks over the years. Each of these sunken ships is soon colonized by reef organisms, and the same type of community is established on these wrecks. Another type of live bottom exists just off the coast at Cape Lookout. This area contains a large area of calico scallops, which are of commercial importance. Section 2.2.3.3 contains more information concerning reef communities.

WETLANDS ARE ECOLOGICALLY VALUABLE NATURAL SYSTEMS

Wetlands are natural communities with vegetation adapted to periodic flooding by salt water or freshwater. Because of high ecological value and important hydrologic functions, wetlands are protected by federal and state regulations. Wetlands may be impacted by water pollution and developments which alter the drainage characteristics of such areas.

Wetlands are considered sensitive areas because of their high ecological value and indirect economic importance. Some of the more valuable functions of wetlands include high biological productivity; providing food, habitat and reproductive areas for many animal and plant species; maintaining natural drainage characteristics, sedimentation patterns, salinity distributions and other hydrologic functions; shielding land areas from wave action, erosion and storm damage; providing storage areas for storm and flood waters; and purifying water through natural filtration processes.

Federal regulation of wetlands is mandated by Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) which directed the Army Corps of Engineers (ACOE) to regulate the discharge of dredged or fill material that could permanently alter or destroy the characteristics of waterways and wetlands. Because wetlands are considered waters of the United States, water quality regulations by the Environmental Protection Agency (USEPA) also apply to wetlands. State laws apply to certain wetland areas; the North Carolina Coastal Area Management Act regulates the use of coastal wetlands, which includes saltmarshes and many brackish marshes.

The ACOE (1978) defines wetlands as those areas that are inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Included by this definition are many natural communities that occur within the barrier island ecosystem: seagrass beds, tidal flats, saltmarshes, freshwater marshes and swamps. More detailed discussions and descriptions of the various wetland community types may be found in the Ecological Inventory (Section 2.2) of this report.

2.0 DESCRIPTION OF THE NATURAL ENVIRONMENT

2.4 Sensitive Areas

2.4.4 Wildlife Nesting Areas

IMPORTANT WILDLIFE NESTING SITES ARE OFTEN LOCATED IN REMOTE AREAS

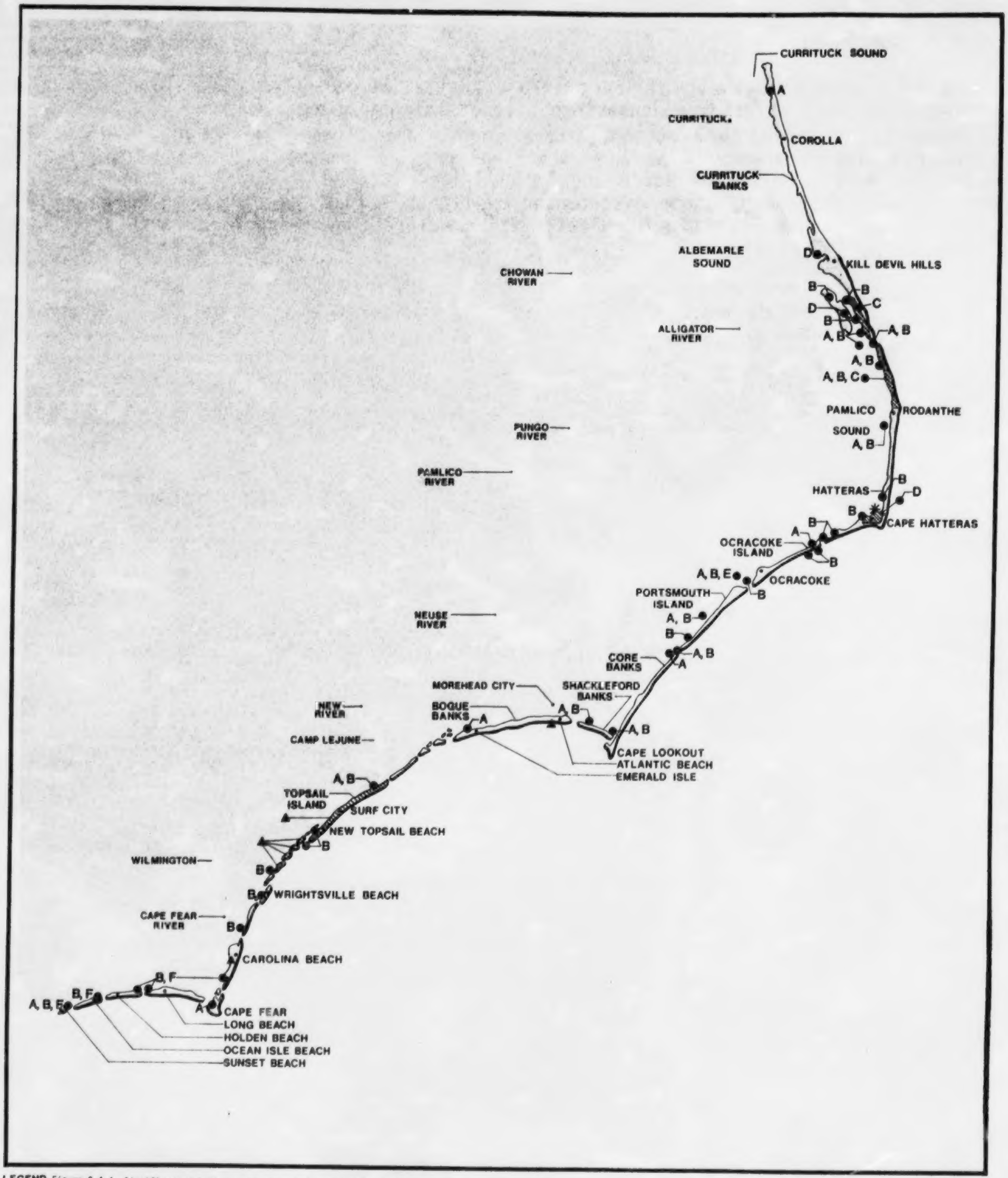
The remoteness of the barrier islands, abundance of food sources and location within major migratory routes have created valuable nesting areas for certain species. Particularly significant nesting populations include many types of birds and loggerhead sea turtles. Isolation is often critical to the continued use of wildlife nesting areas.

Certain areas on the barrier islands are valuable breeding and nesting grounds for wading birds, shorebirds, waterfowl, raptors and other birds. Other significant areas include many of the oceanfront beaches which are used as nesting sites by the threatened loggerhead sea turtles. Habitat for significant breeding populations of rare or unusual wildlife on the barrier islands, such as alligators and white-tailed deer are also considered sensitive areas. Figure 2.4.4 shows the general location of significant wildlife nesting areas on the barrier islands. More specific information regarding such sites may be obtained from several sources, Herons and Their Allies: Atlas of Atlantic Coast Colonies (Osborn and Custer 1978); Atlas of Colonial Waterbirds of North Carolina Estuaries (Parnell and Soots 1979); the Atlantic Coast Ecological Inventory (U.S. Fish and Wildlife Service - FWS 1980); and records from the North Carolina Natural Heritage Program.

The large number of birds which nest on the barrier islands is related to several factors: isolation, close and abundant feeding grounds and location within a major migratory route (the Atlantic Flyway). Particularly noteworthy are the wading bird rookeries, which typically contain large assemblages of herons, egrets, ibis and related birds in dense concentrations and two colonies of the endangered brown pelican. Such rookeries are often located on small, isolated estuarine islands or in remote, densely vegetated sections of larger islands. The ACOE reports that 95 percent of all colonial nesting birds in North Carolina nest on estuarine islands formed from dredged material (Jackson 1981). A usual attribute of such sites is proximity to wetlands.

Large numbers of waterfowl nest, feed, and rest on the barrier islands while migrating along the Atlantic Flyway. Species which are particularly abundant or common include the snow goose, Canadian goose, brant, black duck, pintail, American widgeon, surf scoter and red-breasted menanger (Quay 1979). Important waterfowl nesting and habitat areas are primarily located in the upper sections of the Outer Banks northward of Ocracoke Island. Typical habitats include estuarine bays, saltmarshes and freshwater marshes and ponds.

Loggerhead turtles reach their northern nesting limits around Pea Island (FWS 1980). Female loggerheads generally nest several times during the summer months on the upper beaches of remote shores, with an average of 125 eggs to a clutch (Dean and Talbert 1975). Mortality is often quite high (80-100 percent) on other Southeastern barrier islands where eggs are frequently destroyed by raccoons, feral hogs, and high storm waters. Predation losses appear to be only a nominal problem on most North Carolina beaches, except on Onslow Beach and Smith Island (Crouse 1981). However, hatchling turtles may become disoriented by lights and noises near developed beaches and subsequently die from dessication before they reach ocean waters (Johnson et al. 1974).


CURRITUCK SOUND
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CURRITUCK
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
D
KILL DEVIL HILLS
CHOWAN RIVER
B
B
C
D
B
ALLIGATOR RIVER
A, B
A, B
A, B
A, B, C
PAMLICO SOUND
RODANTHE
PUNGO RIVER
A, B
PAMLICO RIVER
B
HATTERAS
D
B
CAPE HATTERAS
A
B
OCRACOKE ISLAND
B
A, B, E
OCRACOKE
PORTSMOUTH ISLAND
B
NEUSE RIVER
A, B
B
A, B
CORE BANKS
A
MOREHEAD CITY
SHACKLEFORD BANKS
A, B
NEW RIVER
BOGUE BANKS
A
A, B
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
A, B
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
B
WILMINGTON
B
B
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
B
CAROLINA BEACH
B, F
B, F
A, B, F
A
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH

LEGEND Figure 2.4.4 Significant animal nesting areas and breeding populations.

● Birds
- **A** Wading Birds (herons, egrets, rails, ibis)
- **B** Shorebirds (terns, gulls, turnstones, plovers, skimmers, oystercatchers)
- **C** Waterfowl (ducks, geese)
- **D** Raptors (osprey, hawks, kites)
- **E** Pelicans
- **F** Seabirds (petrels, shearwaters, albatrosses, cormorants)

▲ Alligators

✳ White-tail Deer

⬭ Loggerhead sea-turtles

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SCALE IN MILES
5 2.5 0 5 10 15 20 30 40

LIMITED MARITIME FORESTS MAY BE ENDANGERED BY DEVELOPMENT

Maritime forests are limited in extent on the barrier islands. Existing forest stands are particularly vulnerable to future impacts because of the otherwise general suitability of such areas for development. Barrier island forests are valuable wildlife habitats. Providing that tree cover is not significantly altered, some development uses may be compatible with the ecology of these forests.

Significant forest stands are well developed at only a few sites on the barrier islands. These forests include the maritime forest community described in Section 2.2.4.5 of this report. Such forests generally occur on the interior and inland sides of barrier islands where coastal winds and salt spray are somewhat reduced by high dune systems or large island widths. Barrier islands which contain sizable forest stands include Smith Island, Bogue Banks, Shackleford Banks, Hatteras Island at Buxton Woods and Bodie Island near Nags Head and Kittyhawk.

Many of the barrier islands do not contain any significant forest stands because of narrow island widths, burial by wandering sand dunes and low dune elevations. These factors prevent an adequate reduction of environmental factors to allow trees to develop. Humans have also contributed to this paucity by cutting forests for timber or coastal developments, causing fires, and permitting grazing by domestic and feral animals (Bordeau and Oosting 1959). In addition to their rarity, maritime forests are the most valuable wildlife habitats of upland areas on the barrier islands.

Forest sites are often considered prime areas for development because they occur on upland soils in the protected interiors of barrier islands. Some types of development may be compatible with the ecology of forest communities, providing that tree cover is not significantly reduced. Low-density housing has been constructed in forests of barrier islands such as Hilton Head, South Carolina and Saint Simons, Georgia without excessive clearing of trees.

SIGNIFICANT NATURAL AND CULTURAL FEATURES ARE DESIGNATED BY STATE AND FEDERAL GOVERNMENT AGENCIES

Certain areas are designated as Registered Natural Areas by the North Carolina Natural Heritage Program. Such lands contain significant natural features which are valuable to the public interest and vulnerable to development. A number of cultural sites listed by the U.S. National Register and the North Carolina Historic Preservation Section are found on the barrier islands.

Under the administration of the North Carolina Natural Heritage Program, certain sites have been placed on the North Carolina Register of Natural Areas. Such sites include environmental or natural resources of more than local significance in which non-compatible development could result in major or irreversible losses of scientific, educational and aesthetic values. Examples of designated resource areas may include sites containing remnant (threatened and endangered) plant or animal species; outstanding, rare and/or undisturbed natural communities; and unique geologic formations. Table 2.4.6 describes the current Registered Natural Areas on the North Carolina barrier islands, and Figure 2.4.6 shows the locations of these sites.

Detailed information regarding cultural resource areas can be found in Section 3.7. Cultural resource areas are those sites on the barrier islands that have some historic or archeological significance. A number of sites occurring within the study area are listed on the U. S. National Register and by the North Carolina Historic Preservation Section. Known sites of historical and archeological importance are mapped in the Atlas. Many barrier islands have not been surveyed for the existance of additional sites (Baker 1975, Hall 1981, Phelps 1981). Natural areas listed in Table 2.4.6 may also contain sites of archeological importance (Phelps 1981).

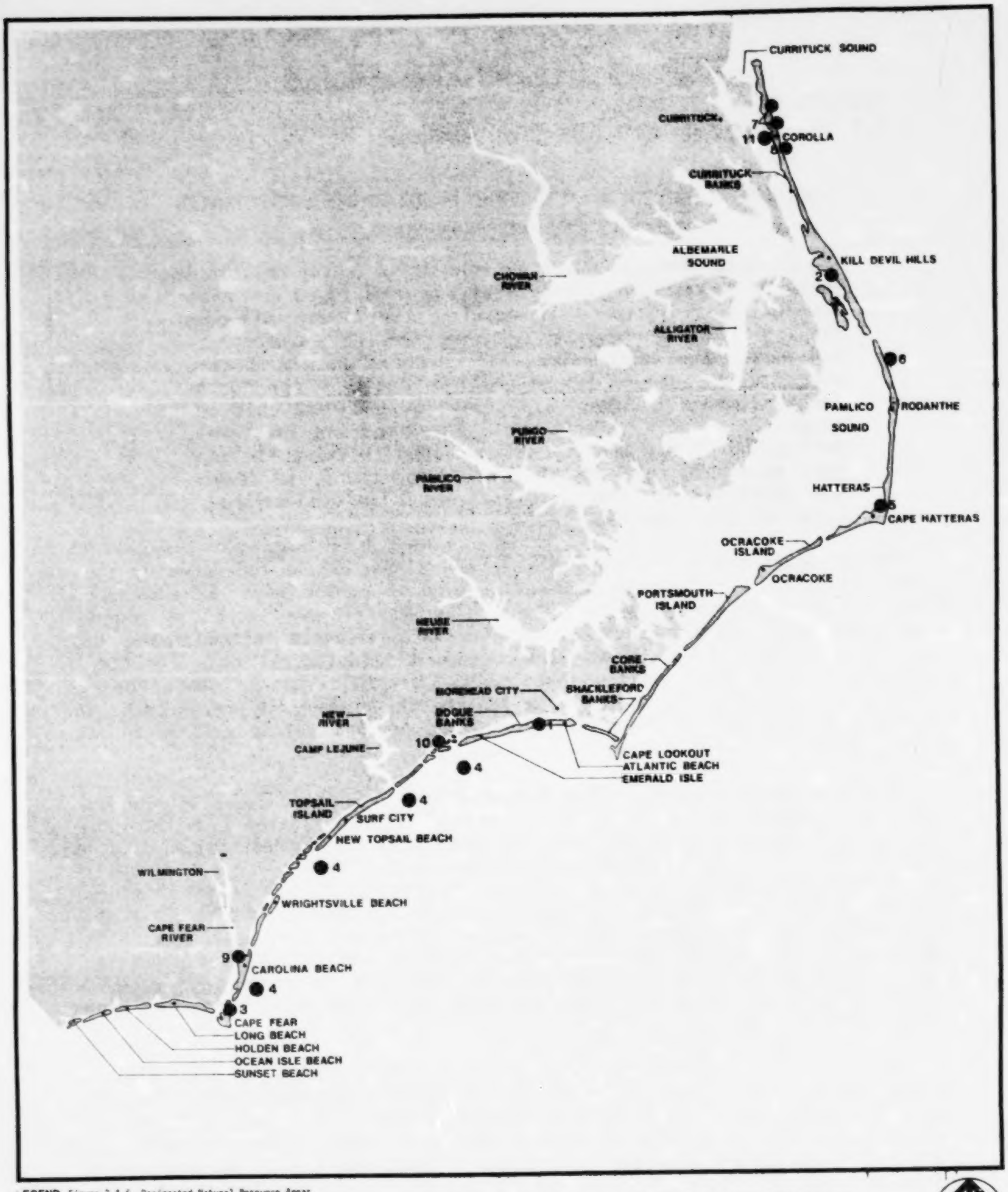
Table 2.4.6. Registered Natural Areas.

Name	Location	Size		Significance
		Hectares	Acres	
1. Roosevelt Natural Area	Bogue Banks-Carteret Co.	107	265	Protected and rare plant & animal species; remnant maritime forest & swamp communities.
2. Nags Head Woods	Bodie Island-Dare Co.	754	1862	Protected and rare plant & animal species; remnant maritime forest & swamp communities; extensive wetlands.
3. Bald Head (Smith) Island Complex	Cape Fear-Brunswick Co.	146	360	Protected and rare plant & animal species; remnant maritime forest; extensive wetlands; northern range limit for several plant & animal species; large wading bird rookery; designated U.S. National Natural Landmark.
4. Onslow Bay Outcrops	Offshore outcrops in Onslow Bay, N.C.-opposite New Hanover, Pender, Onslow, and Carteret Co.'s.	20 15 527 1 563	50 Masonboro; 38 Topsail; 1,300 New River Inlet; 2 Bogue Inlet; 1,390 TOTAL	Biologically diverse marine habitats; unique ecologically productive fishing grounds; high educational and research value.
5. Buxton Woods	Cape Hatteras-Dare Co.	373	920	Protected and rare plant & animal species; extensive remnant maritime forest & swamp communities; unusually high biotic diversity; only significant population of white-tailed deer on the Outer Banks; unique geologic formations.
6. Pea Island National Wildlife Refuge	Hatteras Island-Dare Co.	2,396 11,138	5,915 (land) 27,500 (adjacent estuarine waters)	Protected and rare plant & animal species; extensive wetlands; abundant and diverse wildlife populations--particularly birds; important wildlife nesting areas.

Table 2.4.6. Continued

Name	Location	Size Hectares	 Acres	Significance
7. Monkey and Swan Island Sanctuaries	Currituck Banks-Currituck Co.	2636	6,508	Protected and rare animal species; extensive wetlands; important habitat for migratory birds; large wading bird rookery.
8. Pine Island Sanctuary	Currituck Banks-Currituck Co.	1458	3,600	Protected and rare animal species; extensive wetlands; important habitat for migratory birds; high wildlife diversity.
9. Carolina Beach Natural Area	Carolina Beach-New Hanover Co.	36 113	90 280 (total)	(protected) Protected and rare plant & animal species; numerous wetlands; high habitat diversity; unique geologic formations.
10. Hammocks Beach Natural	Bear Island-Onslow Co. Area	352	870	Protected and rare plant & animal species; remnant maritime forests; extensive wetlands; significant wildlife nesting areas.
11. Currituck Shooting Club Natural Area	Currituck Banks-Currituck Co.	851	2,100	Large variety of habitats supporting a diversity of plant and animal species; valuable waterfowl habitat; protected plant species; geologically noteworthy dune systems; nesting areas.

Source: North Carolina Natural Heritage Program


CURRITUCK SOUND
CURRITUCK
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
KILL DEVIL HILLS
CHOWAN RIVER
ALLIGATOR RIVER
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PAMLICO RIVER
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CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
PORTSMOUTH ISLAND
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NEW TOPSAIL BEACH
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH
1
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11

LEGEND Figure 2.4.6 Designated Natural Resource Areas

1 Roosevelt Natural Area
2 Nags Head Woods
3 Bald Head (Smith) Island Complex
4 Onslow Bay Outcrops
5 Buxton Woods
6 Pea Island National Wildlife Refuge
7 Monkey and Swan Island Sanctuaries
8 Pine Island National Audubon Sanctuary
9 Carolina Beach State Park Natural Area
10 Hammocks Beach State Park Natural Area
11 Currituck Shooting Club Natural Area

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
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GANNETT FLEMING CORDORY AND CARPENTER, INC.

SCALE IN MILES
5 2.5 0 5 10 15 20 30 40

MODERATE CLIMATE AND EXCELLENT AIR RESOURCES CHARACTERIZE BARRIER ISLANDS

The climate along the barrier islands is fairly uniform in terms of temperature, precipitation, wind speed and relative humidity. The most powerful weather along this coast results from the occurrences of tropical storms, hurricanes and northeasters. Generally, no significant air quality, odor or noise problems exist in the North Carolina coastal area. Air pollution problems that do occur are usually intermittent, localized and low level. Monitoring of air quality is conducted at three stations located within the coastal area. Odor and noise levels are monitored or near the barrier islands since no problems have been reported.

The climatic pattern along the barrier islands of is moderated by the waters of the Atlantic Ocean and surrounding estuarine bays and sounds. Winter temperatures are somewhat milder than those experienced in inland areas and summer temperatures are cooler in comparison to inland areas (U.S. Dept. of Commerce 1978). Table 2.5.a shows climatological data for the northern, central and southern parts of the coastal region. These three stations are National Weather Service Stations, and the data presented is for the years from 1941 to 1970. In general, the area is fairly uniform in its weather patterns.

Of these three stations, Cape Hatteras has lower high temperatures and higher low temperatures as a result of being furthest removed from the mainland. The temperatures of the Cape Hatteras area are representative of the outer banks. The precipitation patterns are generally similar all along the coast. The average and maximum wind speeds are also fairly uniform for the data collected from 1941-1970. However, there are events that can and do alter these values, particularly in precipitation and wind patterns. This coastline is affected by storms of both tropical and extratropical origin. These storms occur throughout the year (hurricanes in summer and fall, northeasters in winter and spring) and bring with them heavy rains and winds (Baker 1978).

Section 3.8.1 presents the recent storm history of this area plus probability of future storm events for six zones along the coast. The last large hurricane to hit this coast was Donna in 1960. The years 1954 and 1955 were the most active years with four severe hurricanes. Since the 1960's, no large hurricanes have affected this area. This trend cannot be expected to continue, and this lack of large storms may be the reason for the fairly uniform climate data presented in Table 2.5.1. Since 1960 there have been some large northeaster storms, the most severe being the "Ash Wednesday Northeaster" of March 1962.

2.5 Continued

The existing air quality in the barrier islands is generally good to excellent. Problems that do arise seem to be caused by activity on the more developed coastal areas. These problems stem from industry and agriculturally related land clearing practices.

Air quality monitoring is performed by the Department of Natural Resources and Community Development, Division of Environmental Management, Air Quality Section. No monitoring stations are located on any of the barrier islands. Extrapolation of mainland air quality data to conditions on the islands has been done in some of the 201 Plans prepared for barrier island areas. The applicability of this data, however, is limited since areas immediately adjacent to the Atlantic Ocean, such as the barrier islands, have the benefit of nearly constant air movement due to land/ocean interactions which tend to favor good air quality.

Table 2.5.b lists the air quality data from stations located in or near the study area. The primary criteria pollutant parameters and their limiting standards were established by the Federal Air Pollution Control Act and adopted by the State of North Carolina. They include suspended particulates with a geometric annual mean of 60 ug/m^3 (micrograms per cubic meter of ambient air), sulfur dioxide (SO_2) with an arithmetic annual mean of 60 ug/m^3 and nitrogen dioxide (NO_2) with an arithmetic annual mean of 100 ug/m^3. As can be seen, the suspended particulates are the only pollutant that exceeded the limit. This can be attributed in most cases to air inversions which occur less than 25 percent of the time.

Noise is not considered a significant problem on the barrier islands. No monitoring of noise levels has ever been performed on any of the barrier islands since no problems due to excessive noise levels have ever been reported. Intermittently high noise levels from traffic and airports do occur but are not considered to be significant.

Odor problems are also nonexistent on the barrier islands. Although several areas reportedly have septic tank problems, odors associated with these failures have not been reported. Potential odor problems may be associated with water pollution incidences (fish kills and algal blooms) and septic tank and wastewater treatment plant malfunctions.

Table 2.5.a. Comparative Climatological Data for the Period from 1941-1970 at the National Weather Service Stations of Norfolk, Cape Hatteras and Wilmington.

Observed Data	Norfolk	Cape Hatteras	Wilmington
Temperature - Highest of record	44°C (103°F)	40°C (95°F)	45°C (104°F)
Temperature - Lowest of record	-17°C (5°F)	-13°C (12°F)	-14°C (10°F)
Mean # of days minimum temperature 0°C or less	54	32	42
Mean # of days precipitation	115	112	117
Average total snowfall (incl. ice pellets)	17.8 cm (7.0 in)	4.1 cm (1.6 in)	4.8 cm (1.9 in)
Wind - Average speed	17.1 kph (10.6 mph)	18.5 kph (11.5 mph)	145 kph (9.0 mph)
Wind - Maximum speed (direction/speed)	180°/125.6 kpm (78 mph)	270°/177.1 kpm (110 mph)	360°/141.7 kph (88 mph)
Sunshine - Average percentage of possible	63	59	64
Cloudiness - Mean # of days: clear, partly cloudy, cloudy	110/104/151	106/100/159	114/105/136
Average Relative Humidity (%) - morning/afternoon	78/58	82/66	84/57
Climatological Normals			
Normal daily maximum temperature	22.5°C (68.0°F)	19.9°C (63.8°F)	26.0°C (73.6°F)
Normal daily minimum temperature	11.6°C (50.6°F)	14.4°C (55.0°F)	13.6°C (53.7°F)
Normal daily mean temperature	17.1°C (59.3°F)	18.6°C (61.7°F)	19.8°C (63.7°F)
Normal precipitation	113.49 cm (44.68 in.)	141.27 cm (55.62 in.)	136.12 cm (53.59 i

Source: U. S. Department of Commerce, National Weather Service. 1978.

Table 2.5.b Air Quality Monitoring in Coastal North Carolina.

Pollutant	Elizabeth City	Leland (school)	Leland (Lincoln sch.)	Morehead City	Riegelwood	Wilmington (WTP)	Wilmington (N. Wal.)
Suspended Particulates[1] (Limit = 60)							
1972	43	46	-	76	42	47	47
1973	48	84	-	69	41	55	48
1974	48	-	32	67	37	40	37
1975	-	-	37	-	42	47	37
1976	-	-	-	-	50	48	52
Sulfur Dioxide[1] (Limit = 60)							
1972	5	8	-	34	13	18	13
1973	5	5	-	15	5	11	9
1974	5	0	5	16	5	6	9
1975	-	-	6	-	5	7	7
1976	-	-	-	-	6	6	9
Nitrogen Dioxide[1] (Limit = 100)							
1972	20	22	-	49	23	23	25
1973	11	19	-	30	16	19	20
1974	12	-	16	34	12	13	21
1975	-	-	11	-	12	18	21
1976	-	-	-	-	12	16	21

[1] All values are annual means in micrograms per cubic meter of ambient air.

Source: North Carolina Division of Environmental Management, Air Quality Section, Raleigh, N.C.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

NATURE OF THE BARRIER ISLAND ENVIRONMENT IMPOSES UNIQUE LIMITATIONS ON DEVELOPMENT

The barrier island environment imposes certain limitations on the location and extent of permanent development. Major considerations include water supply, wastewater disposal, and storm and flood hazards. Tourism and recreation form the islands' economic base; without development controls, the natural resources which attract tourists and residents will become degraded.

The unique natural environment of barrier islands offers numerous opportunities for recreation and development serving permanent and seasonal residents as well as tourists. However, because of specific limitations imposed by the environment, development of the barrier islands requires special considerations.

The majority of the acreage on the barrier islands of North Carolina is undeveloped. However, the last decade has seen a significant increase in residential and tourist-related development. Problems created from the rapid development include degradation of environmentally sensitive areas, traffic congestion and surface and groundwater pollution.

The population is comprised of permanent residents and seasonal residents, including tourists. Since 1970 the number of permanent residents has increased by 97 percent from 12,664 to 24,998. Projections indicate a continuation of the rapid growth with a permanent population in 2000 between 500,062 (201 Plan estimates) and 526,600 (EPA estimates). Seasonal populations are expected to grow in absolute numbers far exceeding permanent resident numbers.

Wastewater treatment and disposal is a major concern on the barrier islands and is the focus of this EIS. Most domestic wastewater is treated by conventional soil absorption systems. A few municipal wastewater plants as well as some private package plants discharge to surface waters. Some recently constructed wastewater package plants discharge to the water table aquifers due to state regulations prohibiting discharge to surface waters classified as suitable for shellfish harvesting. Systems discharging to the water table aquifer which currently serve condominiums, apartments and motels on the islands are viable alternatives where suitable conditions exist. Limitations concerning land requirements, possible groundwater effects and the potential for malfunction must be considered. Conventional, on-lot disposal systems are suitable for use on the barrier islands in many areas. However, specific data concerning problems with existing septic tanks are limited. Alternative on-lot disposal systems may be appropriate for use on the barrier islands.

The basis for this Environmental Impact Statement is the submittal of six 201 Facilities Plans which include the extension of sewers on the barrier islands. These plans include Southwestern Brunswick County, Southeastern

Brunswick County, Topsail/Surf City in Pender and Onslow Counties, Carteret County Complex, Hatteras Island and Dare Beaches Complex in Dare County. Except for the Hatteras Island plan, these 201 Facilities Plans call for extensive collector/interceptor sewer systems, including substantial portions of the barrier islands, with centralized treatment facilities and effluent disposal via ocean outfall, discharge into groundwaters, and land application via spray irrigation. Specific details of each plan are discussed in Section 3.3.1.3.

Community services require special consideration when planning for future growth. In most barrier island communities in North Carolina, police protection, water supply and garbage collection are generally a direct responsibility of the towns. Schools, health care facilities, sanitary landfill sites and supplemental sheriff's protection are provided by the counties. Fire protection and rescue squad services are provided by voluntary organizations. A significant problem involves the necessary expansion of community services during the summer months to serve seasonal residents and tourists. This seasonal expansion often exceeds the needs of the resident population and results in an inequitable financial burden.

Access to the North Carolina barrier islands is provided by bridges, causeways and ferry service from the mainland. The most extensive public areas are the Cape Hatteras and Cape Lookout National Seashores. An inventory of state and local access points and facilities indicates adequate beach access in most areas, including the heavily developed areas along the southern portion of the coast.

Tourism dominates the islands' economies and accounts for approximately 7 to 8 percent of the state's travel expenditures. The fisheries industry, including sport fishing, also contributes significantly to the area economy. This dependence on the natural environment necessitates the protection of the land and water resources and emphasizes the need for adequate planning and development controls.

Regulations and development controls that affect the use of land and the natural environment have been enacted at the federal, state and local levels of government. Federal regulations include the National Environmental Policy Act of 1969, the National Flood Insurance Program, the National Pollutant Discharge and Elimination System (NPDES) and the Ocean Disposal Permitting System. The State of North Carolina has also developed regulations that set minimum standards for utilization of resources, including water supplies, land and land cover, and renewable food resources such as shellfish. The North Carolina Coastal Area Management Act also provides specific guidelines and regulations concerning barrier islands. Conventional zoning and subdivision controls are the most widely used methods for guiding development at the local government level. Other local development controls that have been implemented in various jurisdictions include building codes, septic tank regulations, erosion and sediment control ordinances and flood hazard ordinances.

The North Carolina Coastal Management Program deserves special attention due to the comprehensive manner in which it addresses the resource use of the coastal region. The focus of the management plan is to integrate a system of land and water management practices at both the state and local levels. The Coastal Management Program is detailed in Section 3.6.1.4.

Historical and archeological sites on the barrier islands emphasize the maritime history of the area and provide unique educational and recreational benefits. Historical sites which should be preserved include several lighthouses and forts. Archeological resources have not been fully explored on the barrier islands but, nevertheless, deserve special consideration during construction and development activities.

The coast of North Carolina has a long history of impact by tropical storms, hurricanes and northeasters. These storms play a major role in determining the structure of the natural and man-made environments. Hurricane Hazel, which struck the Wilmington area on October 15, 1954, caused an estimated $21,150,000 in damages on the barrier islands and is considered the most severe storm to affect North Carolina in the last century. Increased development since this last great hurricane raises the potential economic risk of barrier island development and increases the likelihood of another major disaster.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.1 Land Use

DEVELOPMENT PLACES STRESS ON BARRIER ISLANDS' NATURAL AND MUNICIPAL RESOURCES

The barrier islands have and will continue to experience residential and tourist-related development along with increased use of its natural resources. Development will continue to stress environmentally sensitive areas and increase the need for public services. The extent to which these impacts will be controlled will largely depend upon the implementation of land use and environmental protection regulations.

The land use analysis for the barrier islands is based primarily upon the plans completed under the North Carolina Coastal Area Management Act (CAMA). The analysis indicates that a considerable portion of the islands' land area is undeveloped. However, these undeveloped areas are largely on beaches, marshes and wetlands, and maritime forests which are experiencing considerable development pressure and increased recreational use.

Trends indicate that the great majority of new development is and will continue to be in retirement, second home, and hotel/motel uses along with commercial uses related to tourism. This new growth and tourism are straining the islands' environmental resources and causing aesthetic degradation and congestion. These forces have created a demand for more public services that must be paid for by a comparatively small resident population.

Market trends point toward higher density development whose realization would be made possible, in part, by the provisions of central wastewater treatment and disposal. In the final analysis, the quality and quantity of new development on the islands will largely depend upon the implementation of land use and environmental protection regulations. The implementation of the state/local partnership for future planning and development of coastal areas under CAMA has been slow. As a result, the nature and impact of new development on island resources remains to be decided.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.1 Land Use

3.1.1 Existing Land Use

EXISTING LAND IS LARGELY UNDEVELOPED WITH INTERSPERSED RESIDENTIAL AND COMMERCIAL USES

A land use analysis indicates that the majority of the barrier islands are publicly or privately owned undeveloped lands. However, during the past two decades, considerable residential and tourist-related development primarily caused by a large increase in seasonal visitation has occurred. This development has expanded usage of the islands' natural and cultural resources.

The barrier islands of North Carolina encompass approximately 167,015 acres. As Table 3.1.1 shows, they are comprised mostly of publicly and privately owned undeveloped land. Undeveloped lands include lands held in abeyance for urban uses, beaches, marsh and wetlands, dune areas, and maritime forests. Presently, large portions of the barrier islands are owned by the federal government, with Cape Hatteras National Seashore and Cape Lookout National Seashore representing the largest single parcels. Public acreages will increase further should the proposed federal purchase of most portions of Bodie Island in Currituck County be realized. More than 8,500 ha (21,000 ac) are developed throughout the barrier islands.

While these statistics appear to indicate that large portions of the islands are relatively untouched, trends show they are experiencing considerable development pressures and increased usage. According to the Heritage Conservation and Recreation Service, the percentage of developed uses in the barrier islands increased from 3.9 percent in 1950 (approximately 2400 ha (5,900 ac) to 13.9 percent in 1974 (approximately 8750 ha (21,600 ac). This information was based on a survey of aerial photography conducted by the U. S. Geological Survey.

The islands' natural and cultural resources coupled with national trends of increasing income, mobility and leisure time have enhanced the islands' desirability as a place for permanent residences and as a major recreational area. Development pressures have been directly related to accessibility from the mainland and availability of privately owned vacant lands. Most development has occurred in and around the islands' incorporated towns. Development has taken the form of residential growth accompanied by tourist related business. Only on that portion of Bodie Island located in Currituck County has development progressed slowly because of access problems.

The development pattern that is characteristic of most beach communities is a linear strip running parallel to the beach front. Most lots are long and narrow. Usually, the greater development density occurs on the beach side and diminishes as one moves away from the beach. The majority of developed acreage is in residential uses with seasonal housing usually exceeding permanent housing. Seasonal housing types range from cottages to duplexes and mobile homes. Commercial uses are generally scattered along major roads. Most commercial development is tourist oriented and includes

Table 3.1.1. Developed and Undeveloped Land on the Barrier Islands.

Island Name	Hectares		Acres		Designation*
	Undeveloped	Developed	Undeveloped	Developed	
Bodie Island South (Currituck Banks)	15,552	2,876	38,400	7,100	Developed/Undeveloped
Hatteras Island (Cape Hatteras N.S.)	6,480	405	16,000	1,000	Developed/Protected
Ocracoke Island (Cape Hatteras N.S.)					Protected
Portsmouth Island (Cape Lookout N.S.)					Protected
Core Banks North (Cape Lookout N.S.)					Protected
Core Banks South (Cape Lookout N.S.)					Protected
Shackleford Banks (Cape Lookout N.S.)					Protected
Bogue Banks	2,309	1,215	5,700	3,000	Developed
Hammock Island (Hammock Beach S.P.)					Protected
Onslow Island (Marine Corps Reservation)					Protected
Ashe Island	2,835	810	7,000	2,000	Developed/Undeveloped
Lee Island		-	1,500	-	Undeveloped
Rich Inlet	527	-	1,300	-	Undeveloped
Figure Eight Island	1,215	405	3,000	1,000	Developed
Wrightsville Beach			-		
Masonboro Island (Carolina Beach S.P.)			Protected		
Carolina Beach Island (Masonboro S.P.)	1,944	891	4,800	2,200	Developed/Protected
Smith Island	2,349	203	5,800	500	Undeveloped
Oak Island	1,620	810	4,000	2,000	Developed
Holden Beach Island	405	405	1,000	1,000	Developed
Hales Beach Island (Ocean Isle Beach)	527	405	1,300	1,000	Developed
Sunset Beach Island					-
Bird Island	122		300	-	Undeveloped

*Note: Developed - 75% or more of the land area is developed or 405 ha (1,000 ac) or more are developed.
Undeveloped - No development, or less than 10% of the land area is developed or 2025 ha (5,000 ac) or more is undeveloped.
Protected - Land is protected in federal and state parks.
No Designation - Between 10% and 75% of the land area is developed and no acreage is protected.

Source: U.S. Dept. of Interior, Heritage Conservation and Recreation Service. 1980.

3.1.1 Continued

motels and hotels, restaurants, gift shops, entertainment facilities and gas stations. Other commercial uses consist primarily of grocery stores, fishing piers with bait and tackle shops, realty offices and laundromats.

The amount of industrial land use is negligible. The absence of a large labor force, adequate transportation routes and large plots of land, plus restrictions imposed by the fragile environmental condition of coastal areas limit industrial development. Most of the remaining developed acreage is dedicated to municipally owned buildings, churches and educational facilities.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.1 Land Use

3.1.2 Existing Development Problems

UNCONTROLLED USAGE AND DEVELOPMENT OF THE BARRIER ISLANDS HAVE RESULTED IN NUMEROUS PROBLEMS

New development and increased tourism have encroached upon the islands' environmentally sensitive areas, contributing to surface and ground water pollution. Large seasonal populations have caused aesthetic degradation, congestion, and traffic problems. New growth and increased tourism have created a demand for public services, the cost of which must be borne largely by a relatively small year-round population.

Historical patterns of unrestricted development and intensive recreational use of the barrier islands threaten their unique historic, cultural and natural resources. Inappropriate development has encroached upon frontal dunes and wetlands and damaged protective vegetation. This, in turn, has accelerated the damage caused by natural phenomena such as storms, erosion, and siltation. High density development on very small lots and on soils such as fill material not suited for their use has strained the effectiveness of on-lot disposal systems placed in marginal soils. Malfunctions can cause pollution of ground and surface waters which will have an adverse impact on the fishing industry and recreational fishing opportunities. Pollution can also contaminate the islands' subsurface water supplies.

High density and mixed commercial and residential uses impair the overall visual quality of the area and do not afford residents privacy and protection from offensive characteristics of extensive commercial uses. In some instances, absentee ownership results in improper maintenance which leads to visual blight.

Peak seasonal populations increase litter and congestion. Due to the linearity of beach areas and two-lane roads, efficient internal movement of traffic is impaired. Commercial, commercial-residential, and residential uses each have individual access to two lane highways, causing traffic hazards and congestion.

One of the most important impacts of expanding development and tourism is an increased demand for government services such as sewer and water service and police and fire protection. This situation is compounded where facilities must meet the demand of a peak season population many times larger than the number of permanent residents. The problem is not only one of economic feasibility but also of equitable distribution of the cost of services and facilities among those who benefit from them.

FUTURE LAND USE PLANS FOR BARRIER ISLANDS INDICATE CONSIDERABLE LAND SUITABLE FOR DEVELOPMENT

Land use plans indicate that 15,874 ha (39,194 ac) can expect significant growth in future years. New growth will be comprised primarily of retirement, second home, and tourist-related development. Increased pressure for higher density development is expected.

Pressures for future development at higher densities will grow because of increasing land costs and the desirability of the islands. The proposed provision of central wastewater treatment and disposal could promote this type of development while minimizing negative water quality impacts from waste treatment systems.

One means of mediating among competing interests will be land use and environmental protection regulations. The 1974 North Carolina Coastal Area Management Act established a state/local partnership for the future planning and development of coastal areas. Except for Areas of Environmental Concern, land use regulation decisions are left with counties and localities. Although all coastal counties and towns have some form of development regulations, most are currently being revised to assure coordination with the development goals of their CAMA plans.

However, based upon current CAMA plans and their future land use definitions, approximately 15,874 ha (39,194 ac) of the Barrier Islands are classified as "transition." Transition lands are those on which moderate to high density development is expected during the next ten years and where necessary public services will be provided. Should current development trends continue, these lands are expected to absorb the majority of new growth in the form of retirement, second home, hotel/motel development along with other service-related uses. Because of the market appeal of the islands and the resultant rising cost of land, increased pressure for higher density development can be expected.

About 11,053 ha (27,291 ac) are classified in "developed" and "community" uses. Developed lands are those with moderate to high population density and a variety of land uses, which already have necessary public services provided. "Community" lands are those where low density development is grouped in existing settlements or will occur in such settlements during the next ten years and will not require extensive public services now or in the future.

Approximately 2,496 ha (6,164 ac) have been classified as "rural" lands whose designated use is agriculture, forestry, mining, water supply, etc., based on their natural resources potential. Also included are lands for future needs not currently recognized.

About 38,218 ha (94,366 ac) have been designated as "conservation." These are fragile, hazard, or other lands necessary to maintain a healthy natural environment and provide for public health, safety and welfare. On the barrier islands, these include beach, dune, wetland and inlet hazard areas. While development may be restricted or prohibited in the future, these lands will be subject to increased usage and stress as people desire additional beach access and recreational fishing opportunities.

BARRIER ISLAND PERMANENT POPULATION NEARLY DOUBLED DURING THE 1970'S AND SEASONAL RESIDENTS FAR EXCEED PERMANENT RESIDENTS

Barrier island communities have shown strong growth rates over the last 20 years, exceeding county, state and national trends. Resident population on the islands still remains below 8 percent of total county population counts. Various methodologies have been employed to tally the fluctuating population of beach communities during the summer season. Most tabulations conclude that summer visitors swell communities by over 1000 percent.

Countywide population data are available for each coastal county from U.S. Bureau of Census counts through 1980. Table 3.2.a shows the figures for each coastal county, township and incorporated town on a barrier island.

Since 1970 the number of permanent residents inhabiting the barrier islands has increased by 97 percent, from 12,664 to 24,998 (including Manteo). This growth rate contrasts with the overall North Carolina growth rate of 15 percent and the coastal county growth rate of 23 percent. Although there was an increase of 12,334 people in barrier island population from 1970 to 1980, this segment amounted to less than 19 percent of the population increase in the eight coastal counties. Also, the total barrier island population of 24,998 represents less than 8 percent of the total county population of 345,668. Land use and environmental conflicts are often associated with such rapid growth.

While some barrier island areas such as Dare County still retain large areas of undeveloped land, other localities, Topsail and Sunset Beach for example, expect to be totally developed within the next 20 years. Once this buildout has occurred, development pressures will be transferred to the other islands. As in the case of Wrightsville Beach, the community is saturated with visitors on many summer days due to total use of parking facilities and roadways (Hooten 1979).

Accurate projections are very difficult to make for permanent populations on barrier islands that are economically dependent on tourism. Since most of the islands were inaccessible by auto before 1940, all of the growth has occurred recently. This fact allows an apparent rapid growth rate while the increase in numbers is minimal. For example, Sunset Beach shows a growth rate of 181 percent from 1970 to 1980, yet the total resident population in 1980 is 304 residents.

USEPA population projections shown in Table 3.2.a were established for USEPA by the Bureau of Economic Analysis in 1978. The figures represent a disaggregation of statewide totals to the county level for use in the 201 facilities planning program, among other uses. These figures are included only to show the variability in projections that can result as a consequence of using different growth assumptions and base data in attempting to determine future population. A comparison of the 1980 USEPA and 201 facilities

Table 3.2.a. Permanent Population Counts and Projections for Counties and Island Communities.

	Census 1960	Census 1970	Census 1980	1970-1980 % Incr.	USEPA Estimates			201-Plan Estimates		
					1980	1990	2000	1980	1990	2000
Brunswick County	20,278	24,223	35,767	48	41,200	55,100	68,500	40,382	59,008	79,762
Holden Beach	-	135	232	72				230	302	360
Ocean Isle Beach	5	78	143	83				132	173	206
Sunset Beach	-	108	304	181				182	239	286
Coswell Beach	-	-	110	-				66	86	107
Long Beach	102	493	1834	272				1771	2324	2886
Yaupon Beach	89	334	569	70				721	947	1176
Carteret County	27,438	31,603	41,092	30	40,300	48,400	55,800	38,100	42,400	45,300
Atlantic Beach	76	300	941	214				660	870	1000
Emerald Isle	14	222	780	251						
Indian Beach	-	-	54	-						
Pine Knoll Shores	-	-	646	-				770	1400	1600
Currituck County	6601	6976	11,089	59	13,100	22,300	38,700	13,500		51,000
Dare County	5935	6995	13,377	91	11,300	16,000	22,600	10,200	14,000	2,000
Atlantic Twp.	864	1141	3737	228						
Kill Devil Hills	268	357	1796	403						
Southern Shores	-	-	395	-						
Hatteras Twp.	1217	1333	2783	109						
Kennekeet Twp.	434	565	1060	88						
Nags Head Twp.	2760	3328	4971	49						
Manteo	587	547	902	65						
Nags Head	-	414	1020	146						

Table 3.2.a. Continued

	Census 1960	Census 1970	Census 1980	1970 1980 % Incr.	USEPA Estimates 1980	USEPA Estimates 1990	USEPA Estimates 2000	201-Plan Estimates 1980	201-Plan Estimates 1990	201-Plan Estimates 2000
Hyde County	5765	5571	5873	5	5800	6100	6700			
Ocracoke Twp.	475	541	658	22						
New Hanover County	71,742	82,996	103,471	25	111,000	136,400	165,600			
Carolina Beach	1192	1663	2000	20						
Kure Beach	293	394	611	55						
Wrightsville Beach	723	1701	2910	71						
Onslow County	86,208	103,126	112,784	9	121,300	127,600	133,200	100,700	108,000	111,400
Pender County	18,508	18,149	22,215	22	23,600	29,300	35,500	18,700	19,900	20,300
Surf City	-	166	391	136						
Topsail Beach	-	108	264	144						

Sources: Southwest Brunswick, Southeast Brunswick, Carteret Co., Hatteras Island, Dare Beaches Complex, and Topsail/Surf City 201 Plans.
U.S. Census 1960, 1970, 1980.
USEPA Population Projections--1980, 1990, 2000.

plan estimates with the 1980 Census data shows a wide range of discrepancies with the actual count, even though some of the estimates were computed as recently as 1978.

The population swells enormously during the summer months, especially around major holidays. This population consists of several distinct categories of people: permanent residents, day visitors, overnight visitors and seasonal residents. It is important to quantify the size of each category because each produces a varying amount of wastewater, which in turn affects the total magnitude of wastewater requiring treatment in the 201 Study Area.

Various methodologies have been employed to determine the peak population for each 201 barrier island location. Topsail/Surf City computed peak population by assigning an occupancy factor to each dwelling unit and motel unit to arrive at a weekend/holiday total, apparently discounting the number of day visitors. Wrightsville Beach calculated its total by tabulating housing and hotel unit occupancy in addition to interpolating day use activity from traffic count figures across the sole access bridge to the city.

All the barrier island communities predict an increasing peak population as second home and commercial development proceeds (see Table 3.2.b). Also, as the median age of the U.S. population increases, more retirees are discovering the moderate climate and relaxed atmosphere of the Outer Banks and are settling on the Outer Banks as permanent residents. These trends, combined with increased leisure time for all sectors of the economy, guarantee that seasonal use of North Carolina's barrier islands will continue to expand.

As an example of the visitation trends, visitor statistics for Cape Hatteras National Seashore have shown general growth of almost 5 percent per year since 1965 when 1,089,200 people visited the Outer Banks. The 1978 figure of 2,043,300 is almost double the 1965 total. Future visitation growth is expected to average 4.5 percent per year resulting in a 1995 visitor total of 3,695,000 people or 23,352 visitors on a peak summer day.

The bulk of the visitation occurs during June, July and August. However, with increasing yearly visitation, additional growth has tended to occur in the months of April/May and September/October. This trend indicates that tourists are reacting to the summer crowds and arranging travel plans for the off season. This trend may indicate an expansion of barrier island use beyond the regular high season.

Table 3.2.b. Peak Day Population Estimates--Seasonal, Permanent, Day Visitors.

201 Planning Area	1980	1990	2000
Southwest Brunswick Co.[3]	13,821	15,204	16,724
Southeast Brunswick Co.[3]	18,322	31,770	-
Topsail/Surf City[3]	17,253	-	-
Carteret County Complex[3]	12,159	(1985) 14187	-
Hatteras Island[3]	7,407	16,758	26,158
Dare County Complex[3]	35,760	50,915	71,022
Other Calculations			
Wrightsville Beach[1]	25,544	45,746	81,924
Hatteras National Seashore[2] (average daily summer figure)	12,710	18,032	23,352

Source: [1] U.S. Dept. of Defense, Army Corps of Engineers. 1980.
[2] U. S. Dept. of Interior. 1979.
[3] 201 Facility Plans

WASTEWATER TREATMENT SYSTEMS

Wastewater treatment and disposal on barrier islands are important considerations due to the value of the surrounding surface waters and the relatively shallow water table aquifer. Septic tanks and other soil absorption systems are currently the primary methods of wastewater treatment and disposal on North Carolina barrier islands. Proposed 201 Facility Plans call for extensive sewerage systems and regional wastewater treatment plants.

Wastewater treatment and disposal on barrier islands require special consideration because of the importance of water quality in the ocean and estuaries, the uncertainties of tides and currents, and the potential for degradation of the shallow water table aquifer. In North Carolina, wastewater treatment and disposal are further constrained by regulations which prohibit wastewater discharge to most surface waters and by soil conditions which limit the use of conventional septic tank/soil absorption systems in some areas.

Currently, most domestic wastewaters generated on the barrier islands are treated using conventional septic tanks and other soil absorption systems. Some areas are served by conventional collection systems and municipal treatment plants. Package treatment plants serve commercial developments and higher density residential areas and discharge either to surface waters, subsurface nitrification fields or surface soil absorption systems. Several industrial wastewater sources associated with the seafood processing industry also discharge to surface waters.

In response to actual and perceived wastewater disposal problems, six 201 Wastewater Facilities Plans have been prepared for coastal North Carolina. These plans call for providing sewers and conventional treatment plants to serve the Dare County beaches, Carteret County beaches, Topsail-Surf City, Southeastern Brunswick County and Southwestern Brunswick County. Effluent disposal options include discharge via ocean outfall, land application and discharge to other surface waters. The Hatteras Island Plan found that a centralized sewer system is not cost-effective at this time.

MOST DOMESTIC WASTEWATERS GENERATED ON BARRIER ISLANDS ARE TREATED BY SEPTIC TANK/SOIL ABSORPTION SYSTEMS

Most domestic wastewaters generated on barrier islands are treated by conventional soil absorption systems. A few municipal wastewater treatment plants as well as some private package plants discharge to surface waters. Other private package plants discharge to the water table aquifer. Most industrial discharges on the barrier islands are associated with the seafood processing industry. Most industrial discharges are to surface waters.

Most of the domestic wastewaters generated on or near the barrier islands are treated using septic tank soil absorption systems. However, some municipal wastewater treatment plants serve barrier island and nearby inland communities such as Carolina Beach, Kure Beach, Wrightsville Beach, Morehead City and Southport. In addition, many package plants serve small developments, condominiums, motels and other commercial establishments. The municipal wastewater treatment facilities as well as some package plants discharge to surface waters. Because the discharge of treated domestic wastewaters to SA waters has been prohibited by state regulation, package plants constructed on the barrier islands in recent years discharge to the water table aquifer, either by subsurface nitrification fields or distribution on the surface sands.

Industrial discharges on the barrier islands are associated primarily with the seafood processing industry. Although many of the seafood processors discharge to SA waters, measured water quality violations have not been associated with existing industrial discharges. A new .377 mgd advanced secondary treatment plant has been constructed in conjunction with the Wanchese Harbor project.

The following sections provide greater detail about existing facilities with regard to discharge mode: surface water, water table aquifer and on-site soil absorption.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT
3.3 Wastewater Treatment
3.3.1 Existing Wastewater Systems
3.3.1.1 Surface Water Discharges

SURFACE DISCHARGE OF TREATED DOMESTIC WASTEWATERS IS LIMITED IN THE BARRIER ISLAND AREAS

Because of the state regulation which prohibits discharge of treated domestic wastewaters to SA waters, there are limited surface water discharges in the barrier island areas. Some facilities, however, discharge to surface waters near the barrier islands. These include several municipal wastewater treatment plants as well as some private package plants. Generally, chronic water quality violations are not associated with the discharge from these plants.

Surface water discharges in the barrier island areas are located in the Atlas, Water Resources Map, and described in Table 3.3.1.1. Most barrier island domestic wastewater treatment plants discharge to SC waters that could be classified SA if not for the wastewater discharge. These include such facilities as the Ocean Acres package plant in Dare County and the Wrightsville Beach municipal plant. These discharges were in existence prior to the classification of the state's waters; the regulation prohibiting discharge to SA waters was adopted at a later date. When the waters were classified, limited areas around the existing discharges were classified SC instead of SA to reflect the existing use of the waters for treated waste assimilation. The US Coast Guard stations at Oregon Inlet and Hatteras Inlet do, however, discharge to SA waters. The Villas package plant in Dare County also discharges to SA waters (Roanoke Sound).

With the exception of the SC waters in the areas of existing discharges, all waters on the mainland side of the barrier islands are classified SA. The prohibition of treated wastewater discharge to SA waters has, therefore, essentially eliminated conventional treatment and surface discharge as a possible alternative for handling domestic wastewater generated on the barrier islands.

According to the staff of the North Carolina Division of Environmental Management, there are presently no chronic water quality problems associated with surface water discharges in barrier island areas. It appears that the major impact of these discharges is closing of shellfishing beds to form a buffer zone around the discharge in case of high bacterial counts. In this sense these discharges limit the use of some waters for shellfishing. In addition, the potential for treatment plant malfunction is a constant threat to water quality.

Table 3.3.1.1 Domestic Wastewater Treatment Plants with Surface Water Discharge.

Treatment Facility	Location	Type/Description	Hydraulic Capacity (mgd)	Receiving Waters/ Classification	Sludge Disposal Method	Remarks
OUTER BANKS-VA. STATE LINE TO OCRACOKE						
1. Ocean Acres Utilities	Kill Devil Hills	Advanced secondary; contact stabilization, gravity filtration, chlorination	0.06-design 0.016-existing	Buzzard Bay/SC (West of fresh water pond)		Poor maintenance, problems with meeting effluent limits
2. The Villas Condominium	Kill Devil Hills	Advanced secondary; extended aeration, filtration & chlorination	0.06 (0.012)	Buzzard Bay/SC (between Collington Is. and and Mann Point)		
3. Manteo Municipal WWTP	Manteo	Secondary; contact stabilization (aeration, clarification and sludge reaeration) and chlorination		Shallowbag Bay/SA Shallowbag Bay/ SA	Aerobic digestion and landspreading	Domestic/commercial wastewaters; Shallowbag Bay suffers water quality violation with respect to coliform and DO
4. Oregon Inlet USCGS		Package plant; extended aeration	.010-.015	Oregon Inlet/SA		Discharge to dredged access area
5. Hatteras Inlet USCGS	Town of Hatteras southeast of town	- -	- -	Pamlico Sound/ Freshwater Pond	- -	
6. Buxton Inlet USCGS	Buxton Island along Roanoke Is. causeway	No treatment	0.002	Roanoke Sound/SA	-	Industrial waste that includes packing and cleaning wastes (meets effluent limitations)
BOGUE BANKS-FORT MACON TO BOGUE INLET						
7. Beaufort Municipal WWTP	Beaufort	Secondary (Class II); complete mix activated sludge, chlorination	0.75	Taylor's Creek	Aerobic digestion, dewatering by sand drying beds, and final disposal to sanitary landfill	Some suspended solids violations
8. USDC-NOAA Atlantic Estuarine Fisheries Center	Beaufort		0.1	Beaufort Canal	-	
9. Morehead City Municipal WWTP	Morehead City	Primary clarifier, high trickling filter, secondary clarifier and chlorination	1.7	Calico Creek/SC	Anaerobic digestion, dewatering by sand drying beds, and final disposal to landfill	Occasional violations of average BOD_5 and TSS limits. Shellfishing waters in Calico Creek closed due to coliform.

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Table 3.3.1.1. Continued

Treatment Facility	Location	Type/Description	Hydraulic Capacity (mgd)	Receiving Waters/ Classification	Sludge Disposal Method	Remarks
10. Swansboro Municipal WWTP	Swansboro	Advanced secondary; oxidation ditch extended aeration, multi-media filtration and chlorination	0.3	Fosters Creek/SC	Aerobic digestion, dewatering or sand drying beds and final disposal in Onslow Co. landfill	Newly constructed, fast
11. Swansboro Municipal Water Plant		Swansboro	-	Atlantic Ocean/SB	-	Domestic Waste
12. Fort Macon USCGS East of Atlantic Beach		-	-		-	
13. Newport STP	Newport	Package type contact stabilization plant with chlorination	0.25	Newport River	Anaerobic digestion sand bed drying	Domestic Waste
TOPSAIL ISLAND						
14. Holly Ridge Municipal WWTP	Holly Ridge (mainland)	Imhoff tank (inoperative)	-	King Creek/SC	-	Essentially a raw discharge; contaminates all shellfishing waters in King's Creek below discharge
15. Onslow Beach USMC	Onslow Beach	-	-	-	-	
WRIGHTSVILLE BEACH AND MASONBORO ISLAND						
16. Wrightsville Beach	Wrightsville Beach	Activated Sludge, tertiary treatment with chlorination	0.87	Shell Island Sound (via Stokely Channel)	-	
17. Wrightsville Village Mobile Home Park	New Hanover	Aeration	0.0083-design 0.0002-existing	Intracoastal Waterway/SA (near Bridge Tender Restaurant, south of Wrightsville Beach Bridge)	-	
18. Bowden Nursing Home	Wrightsville Harbor Area	Aeration with chlorination	0.012-design 0.010-existing	Intracoastal Waterway/SC (north of the Wrightsville Beach Bridge)		-
19. Bridge Tender Restaurant	New Hanover	Tertiary with chlorination	0.007-design 0.003-existing	Intracoastal Waterway/SC		-
20. Waterway Motor Lodge	Wrightsville Harbor area	Aeration with chlorination	0.0065-design 0.005-existing	Intracoastal Waterway/SC		-

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Table 3.3.1.1 Continued

Treatment Facility	Location	Type/Description	Hydraulic Capacity (mgd)	Receiving Waters/ Classification	Sludge Disposal Method	Remarks
21. Babies Hospital, Bio-Medical Laboratory and Development Evaluation Center (ABC Development Co.)	New Hanover	Tertiary filters with chlorination	0.015-design 0.012-existing	Intracoastal Waterway/SC		-
22. Davis Nursing Home	Mainland, west of Rich Inlet	Secondary (aerobic) with chloriation	0.020-design 0.010-existing	farm pond	-	
23. Plaza East Shopping Center (Old F&G Development Co.)	Wrightsville Harbor Area	Aeration with chlorination	0.025-design 0.018-existing	Intracoastal Waterway/SA (via Motts Pond)		-
CAROLINA BEACH ISLAND						
24. Carolina Beach WWTP	Carolina Beach	Contact stabilization (Walker Process) with chlorination	1.5	Cape Fear River/SC	Sludge Lagoons	
25. Pirates Cove	New Hanover	-	0.05	Hewletts Creek	-	
26. Fort Fisher USAF	Brunswick	-	0.025	Cape Fear River/SC	-	
27. Kure Beach WWTP	Kure Beach	Secondary	0.1	Cape Fear River/SC	-	Will be abandoned
LONG BEACH ISLAND						
28. Southport WWTP	West St., Southport (north of yacht basin)	Secondary using biological treatment (aeration contact stabilization process) with chlorination	0.30-design 0.24-existing	Cottage Creek (tributary to the Intracoastal Waterway)/SA	On-site	
29. Southport Small Boat	Waterfront of Southport	-	-	Intracoastal Waterway, Cape Fear River/SC		-
30. Southport Marina,	Inc. West Street, Southport	-	-	Intracoastal Waterway/SC		-

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

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3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT
3.3 Wastewater Treatment
3.3.1 Domestic Wastewater Treatment Systems
3.3.1.2 Discharge to Water Table Aquifer

NON-DISCHARGE PACKAGE PLANTS ARE WIDELY USED ON BARRIER ISLANDS

The second type of domestic wastewater treatment plants are those that discahrge their effluent into the water table aquifer. They are generally termed non-discharge systems because they do not discharge to surface waters. The use of these non-discharge systems has increased since the prohibition of discharges to SA waters. They are now widely used on barrier islands to handle wastewaters from condominiums, apartments, motels, restaurants and denser residential development.

Since discharge of treated wastewaters to SA waters is prohibited by state regulations, the use of package treatment plants with effluent discharge to the water table aquifer has increased. These systems are used to serve facilities such as condominiums, motels, apartments or dense residential development and generally provide tertiary treatment of wastewaters consisting of secondary biological treatment followed by positive solids removal prior to disposal. Two types of groundwater discharge systems, subsurface nitrification fields and rotary distribution systems, distribute treated effluent on the ground surface (see Table 3.3.1.2) Nitrification fields are used extensively. The package plant serving the Holiday Inn at Nags Head is an example of the second type, a rotary distribution system. Both types of systems are generally referred to as non-discharge systems because they do not discharge to surface waters.

Even though treatment with groundwater discharge is a widely used treatment technique in the study area, some application limitations exist. One limitation is that the land area requirements are substantial (232 m^2) (2,500 ft^2) of green area for every thousand gallons of wastewater, thereby limiting its use in high-density developed areas. This could be viewed as an asset because it provides for some open space in the developing areas. However, pressure for using centralized sewerage facilities and wastewater disposal on the mainland or in the ocean rather than using high cost barrier island land is expected to increase.

A second limitation is the lack of available discharge sites if the treatment plant malfunctions foul the discharge areas. There have been times in the past when partially treated wastewater has been diverted to surface drainage ditches during periods of treatment plant malfunction. This problem can generally be mitigated, however, by providing duplicate treatment units.

Another limitation to using these non-discharge systems is their possible effects on groundwater and surface waters. Some self-monitoring data from the Holiday Inn at Nags Head indicates that bacterial contamination of groundwater does not appear to be a problem if the effluent is properly disinfected. No reliable data are available on nitrates, chlorinated organics or other possible groundwater pollutants discharged from these systems. Also,

Table 3.3.1.2. Wastewater Treatment Plants with Groundwater Discharge.

Treatment Facility	Location	Type*/Description	Hydraulic Capacity (MGD)	Remarks
OUTER BANKS-VA. STATE LINE TO OCRACOKE				
31. Ocean Sands	Currituck County	Tertiary-nitrification field	0.1	Problems with facility on several occasions
32. Holiday Inn	Nags Head Beach (Kill Devil Hills)	Tertiary-extended aeration, sand filters and chlorination	0.03	Domestic Wastes
33. Armada Inn	Whalebone Junction	Tertiary-extended aeration, filtration and chlorination	0.03	Domestic wastes (odor from oversized pump station wet well)
34. Evans Seafood Restaurant	Nags Head Beach (Kill Devil Hills)	Secondary-extended aeration and chlorination	0.01	Domestic and commercial wastes
35. Sails Condominium	Whalebone Junction	Tertiary	0.007	
36. Dune Lantern Condominium	Whalebone Junction	Tertiary	0.064	
37. Sea Scape Development	Kitty Hawk	Tertiary	0.08	
38. Dunes Condominium	Kitty Hawk	Tertiary	0.03	
BOGUE BANKS-FORT MACON TO BOGUE INLET				
39. A Place at the Beach I and II	Pine Knoll Shores	Tertiary with chlorination - nitrification field	0.02	
40. Balwade Ocean Terrace Condominium	Pine Knoll Shores	Tertiary with chlorination - nitrification field	0.012	
41. The Bluffs Condominium	Morehead City	Tertiary with chlorination - nitrification field	0.009	
42. Brandywine Bay	Morehead City	Tertiary with chlorination - nitrification field	0.05	
43. Carteret Manufacturing	Morehead City	-	0.008	
44. Clam Digger Motel	Pine Knoll Shores	Tertiary with chlorination - nitrification field	0.025	
45. Coral Bay West Condominium	Pine Knoll Shores	Tertiary with chlorination - nitrification field	0.02	
46. Country Club Apartments	Morehead City	-	0.018	
47. 8 1/2 Marina Village	Atlantic Beach	Tertiary with chlorination - nitrification field	0.03	
48. Ramada Inn	Pine Knoll Shores	Tertiary with chlorination - nitrification field	0.02	
49. Tar Landing	Atlantic Beach	Tertiary with chlorination - nitrification field	0.052	
50. West Pine Knoll Shores	Pine Knoll Shores	Tertiary with extended aeration and high rate filters	-	
51. Ocean Glen	Pine Knoll Shores	Tertiary with extended aeration and high-rate filters	-	
52. Ocean Terrace	Pine Knoll Shores	Tertiary with extended aeration and high-rate filters	-	
53. The Oceans	Pine Knoll Shores	-	-	

*Tertiary treatment type refers to secondary biological treatment followed by positive solids removal.
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Table 3.3.1.2 Continued

Treatment Facility	Location	Type*/Description	Hydraulic Capacity (MGD)	Remarks
TOPSAIL ISLAND				
54. North Topsail Shores	Next to New River Inlet (South Side)	Extended aeration, high rate filters and chlorination-nitrification fields	-	
55. Carolina Meat Processors	-	Aeration with chlorination spray irrigation	0.038-design 0.032-existing	
WRIGHTSVILLE BEACH AND MASONBORO ISLAND				
56. Wrightsville USCGS	Wrightsville Beach	-	-	
57. Millbrook Subdivision	-	-	-	
*Tertiary treatment type refers to secondary biological treatment followed by positive solids removal				
LONG BEACH ISLAND				
58. Merrit Moore Seafood	-	-	-	Fish Process Waste
59. Oak Island USCGS	West of Fort Caswell	-	-	
60. Fort Caswell Baptist Retreat	East end of SR1100 at mouth of Cape Fear River	Subsurface drain fields	-	
SOUTHWEST BRUNSWICK COUNTY				
61. Carolina Shores Subdivision	Near Calabash	Tertiary with aeration and spray irrigation on an undeveloped golf course	0.31-design	

*Tertiary treatment type refers to secondary biological treatment followed by positive solids removal.

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

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3.3.1.2 Continued

little is known regarding the leaching of nutrients from these systems to the surface waters.

Besides actual physical limitations, some management problems are associated with package plant systems. As the number increases, it becomes increasingly difficult for the Division of Environmental Management to insure that the plants are adequately operated and maintained. Despite all the potential limitations, however, the non-discharge package plant appears to be a viable wastewater treatment alternative to handle larger wastewater flows in areas where centralized sewerage facilities do not exist.

3.3.1.3 Septic Tank/Soil Absorption Systems

A MAJOR PORTION OF THE STUDY AREA'S POPULATION IS SERVED BY ON-LOT DISPOSAL SYSTEMS

On-lot septic tank/soil absorption systems serve individual residences, apartments and condominiums, and commercial establishments such as motels and restaurants. The continued use of these conventional septic tanks has been questioned. Extensive monitoring and study is needed to evaluate the effect of these systems on the local surface and ground waters.

The major portion of the permanent and seasonal population in the area is served by septic tank/soil absorption systems. These include the systems larger than 11,370 l (3,000 gal) permitted by DEM that serve commercial establishments (see Table 3.3.1.3.a) as well as smaller systems, permitted by the county health departments, that serve the smaller commercial establishments and residences. Estimates of the 1980 peak summer populations served by on-lot disposal systems are provided in Table 3.3.1.3.b. This summer population of 128,078 generates a wastewater discharge of approximately 34,110-37,900 m^3/d (9-10 mgd).

Because of the increasing magnitude of the total wastewater discharge associated with these systems, considerable concern has been expressed regarding their treatment effectiveness and reliability. This concern is based on the general belief that some areas of the barrier islands appear to be unsuitable for conventional septic tank use and that with increased development over the years, there has also been an increase in shellfish bed closures. Specific data on the actual effects of these septic tank systems are limited; however, in recent years, efforts have been made to provide such data.

The Surf City-Old Settlers Beach investigation reports (USEPA/NCDEM 1975) provide data from monitoring shallow groundwater wells and surface waters located adjacent to septic tank systems during different climatological conditions. The data generally indicate that in the limited area of sampling, septic tank systems contribute to contamination of surface waters and groundwaters. Preliminary findings from recent investigations conducted by USEPA and DEM in the Calabash area, indicate that septic tanks may be a cause of bacterial contamination in that area. More general studies indicate that coastal soils may not effectively remove viruses from septic tank discharges (Sobsey and Scandura 1981).

Although the studies generally indicate that conventional septic tank systems may cause water quality problems in specific instances on the barrier islands, there is still a lack of data assessing the overall impacts and the potential for continued widespread or limited use of on-lot systems.

Table 3.3.1.3.a. Septic Tanks/Soil Absorption Systems.

Treatment Facility	Location	Type/Description	Hydraulic Capacity (MGD)	Remarks
OUTER BANKS-VA. STATE LINE TO OCRACOKE				
62. Sandpipers Trace Ltd.	Roanoke Island	Septic tanks and nitrification fields	0.06	Domestic Waste
63. Fort Raleigh National Historic Site	Roanoke Island	Septic tanks and nitrification fields	0.01	Domestic Waste
64. Nags Head Nursing Home	Nags Head Island	Septic Tank	-	
65. Avon KOA Campground	Pea Island, Dare County	Septic tanks, sand filter, chlorination-nitrification field	0.02	Odor from filters
BOGUE BANKS-FORT MACON TO BOGUE INLET				
66. Holiday Inn	Atlantic Beach	Septic Tanks	0.012	
67. Smugglers Cove	Atlantic Beach	Septic Tanks	0.016	
WRIGHTSVILLE BEACH				
68. Bradley Creek Marina	Bradley Creek, West of Wrightsville Beach	Septic Tank with 55.7 m^3 (600 $ft.^2$) drainfield	0.001	
LONG BEACH ISLAND				
69. C.B. Caroon Crab Co.	-	Septic Tank	0.002	Fish Process Waste
70. N. C. Menhaden Co.	-	Septic Tank	0.003	Fish Process Waste
71. Skippers Fish House	-	Septic Tank	0.007	Fish Process Waste
72. Standard Products	-	Septic Tank	0.070	Fish Process Waste

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

Table 3.3.1.3.b. Estimated Peak Summer Population Being Served by On-Lot Disposal Systems in 1980.

Area	Population(1)	Comments
Outer Banks	40,417	Includes parts of Currituck County, Dare Beaches and Wanchese
Bogue Banks	35,971	Includes East Bogue Banks, Cape Carteret, West Bogue Banks and the unincorporated areas outside Morehead City and Newport on the mainland
Topsail Island	19,950	Includes Topsail Beach, Surf City, West Onslow Beach and the unincorporated soundfront areas of Pender County
Long Beach Island	20,450	Includes Long Beach, Caswell Beach, Yaupon Beach and the unincorporated areas in the facility planning area
Holden Beach, Ocean Isle, and Sunset Beach	11,290	Also includes remaining areas within the facility planning area such as Calabash and Shallotte
TOTAL	128,078	

(1) Sources for population estimates and methodology presented in Appendix 3.3.1.3.

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

3.3.1.3 Continued

Alternative on-site disposal systems may be appropriate for use on barrier islands. Although there is limited experience with these systems on barrier islands, recent studies conducted by North Carolina State University in the coastal area indicate that alternative on-site treatment technologies may overcome the limitations to using conventional septic tank/soil absorption systems. A discussion of the use of alterntive on-site systems in barrier islands is contained in Section 3.3.3 and Appendix 3.3.3.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.3 Wastewater Treatment

3.3.1 Existing Wastewater Systems

3.3.1.4 Industrial Wastewater Systems

INDUSTRIAL WASTEWATER DISCHARGES ON BARRIER ISLANDS GENERALLY ASSOCIATED WITH SEAFOOD PROCESSING

The only significant industrial activity in the barrier islands is seafood processing and packing. Wastewaters from these operations are often discharged into SA waters. However, no major adverse impacts from the discharges are apparent.

Industrial wastewater discharges in barrier island areas are noted in Table 3.3.1.4. With the exception of a few water treatment facilities and one laudromat, all the industrial wastewater discharges are associated with some type of fish/seafood processing wastes. Although many of the seafood processors discharge to SA waters, impacts on water quality are very localized and are not considered significant (Mulligan and Wakild 1981). There are no measured water quality violations associated with the existing industrial discharges, and these industrial discharges are generally not considered a major influence on water quality.

One of the most significant developments with respect to industrial wastewater treatment is the construction of the large seafood processing center and shipyard at Wanchese. When operations of the facilities begins, this will be the largest concentration of industrial activity in the immediate vicinity of barrier islands. A 1429 m^3/d (0.377 mgd) advanced secondary treatment plant has been constructed to handle wastewaters from the seafood processors. Although there is no direct discharge from the shipyard activities, some concern has been expressed about possible heavy metals and organic contamination resulting from sandblasting and painting of fishing boats (Mulligan 1981).

Table 3.3.1.4 Industrial Surface Water Discharge.

Treatment Facility	Location	Type/Description	Hydraulic Capacity (mgd)	Receiving Waters/Classification	Sludge Disposal Method	Remarks
Outer Banks-Va State Line to Ocracoke						
Wanchese Harbor Seafood Processing Plant	Wanchese, Roanoke Island	Advanced secondary	0.377	Mill Creek near Wanchese/SC	-	
Buxton Water Treatment Plant	Buxton, Hatteras Island	-	-	Pamlico Sound	-	
Daniels Seafood	Island along Roanoke Island Causeway	No treatment, direct discharge	0.002	Roanoke Sound via Canal/SA	-	Industrial waste that includes packing and cleaning wastes (meets effluent limitations)
Oden Fish and Oil	Hatteras Village	Secondary; primary sedimentation, extended aeration, clarification and disinfection by ultra-violet light	0.0075	Cape Creek/SC	-	
The Washbasket Laundrymat	Buxton					
South Point Fish and Crab	Town of Ocracoke	No treatment	0.001	Silver Lake	-	Reverse osmossis water plant
Ocracoke Water Plant	Town of Ocracoke	-	0.04	Pamlico Sound	-	
Bogue Banks-Fort Macon to Bogue Inlet						
Beaufort Fisheries Inc.	Beaufort	-	3.0	Taylor's Creek/SC	-	Menhaden processing wastes
Brunswick Navigation Co.	Beaufort	-	2.3	Taylor's Creek/SC	-	Menhaden processing wastes
Standard Products	Beaufort	-	1.8	Taylor's Creek/SC	-	Includes untreated evaporator condensate and water from air pollution control devices
Standard Products	Morehead City	-	1.8	Bogue Sound/SA	-	Menhaden processing Wastes
Coastal Zone Corporation of N.C.	Morehead City	-	1.8	Bogue Sound/SA	-	Seafood processing (experimental)

Table 3.3.1.4 Continued

Treatment Facility	Location	Type/Description	Hydraulic Capacity (mgd)	Receiving Waters/Classification	Sludge Disposal Method	Remarks
Dickel, Inc. (Culligan Water Softening Co.)	Morehead City	-	0.009	Bogue Sound/SA	-	Water softening discharge (TDS Source)
R. W. Jones Fish Co.			0.008	Bogue Sound/SA	-	Seafood processing wastes
Wrightsville Beach and Masonboro Island						
Buriss Shrimp	-	-	-	-	-	-
Carolina Beach Island						
Pfizer	Southport	Secondary	1.59	Cape Fear River/SA	-	Chemical processing wastes
Standard Products	Brunswick	-	-	Intracoastal Waterway/SA	-	Menhaden processing wastes

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

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201 FACILITIES PLANS PROPOSE TREATMENT FACILITIES THAT WILL AFFECT NORTH CAROLINA'S BARRIER ISLANDS

The plans for Southwestern Brunswick County, Southeastern Brunswick County, Topsail/Surf City in Pender and Onslow Counties, Carteret County Complex, Dare Beaches Complex in Dare County and Hatteras Island Plan in Dare county have been submitted.

The Dare County Beaches 201 Facilities Plan includes a collection system to service most of Roanoke Island and the barrier island beaches. The proposed regional treatment facilities will be located at Nags Head and will provide secondary treatment with a design flow capacity of 13,644 m^3/d (3.6 mgd). Effluent disposal will be via ocean outfall.

The Carteret County 201 Facilities Plan proposes three treatment and disposal systems to separately serve the East Bogue Banks area, Beaufort, and Newport and Morehead City. New treatment and collection facilities are planned to serve the East Bogue Banks area with effluent disposal via ocean outfall.

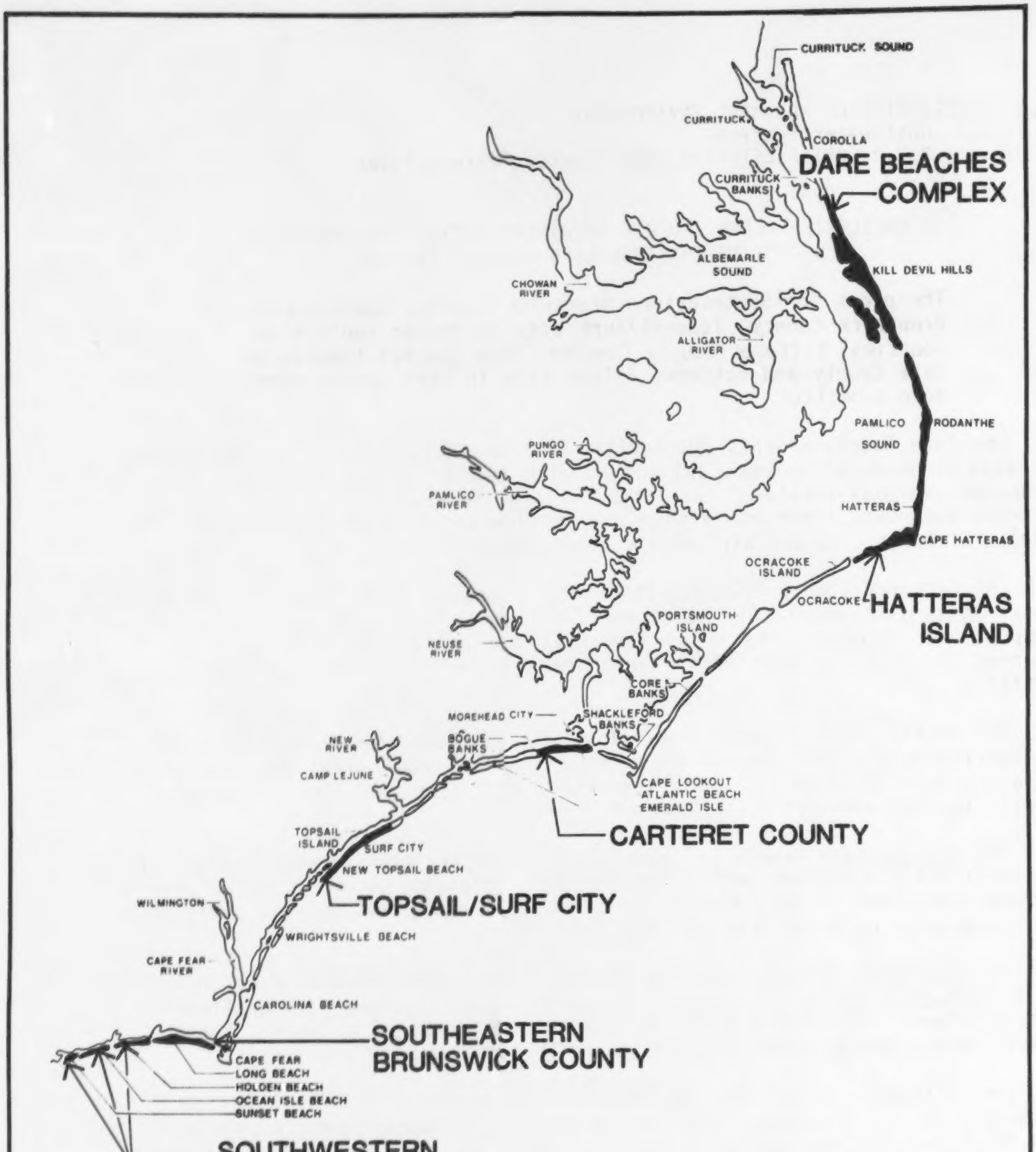
The Topsail-Surf City 201 Facilities Plan include the construction of a collection/interceptor system to service the developed areas on Topsail Island. An 8717 m^3/d (2.3 mgd) stabilization lagoon and spray irrigation facilities are proposed for a mainland site.

The Southeastern Brunswick County 201 Facilities Plan proposes expansion of Southport's treatment and collection facilities to service parts of Oak Island (the towns of Long Beach, Yaupon Beach, and Caswell Beach). Effluent discharge will continue into the Cape Fear River.

The Southwest Brunswick County 201 Facilities Plan proposes five individual collection systems, secondary treatment facilities and land application sites. These localized systems will serve the areas of Calabash, Sunset Beach, Holden Beach, Ocean Isle Beach and Shallote (on the mainland).

The Hatteras Island 201 Facilities Plan examined several sewering alternatives and concluded that central wastewater management systems will not be cost-effective during the 1980's.

The six 201 Facilities Plans are discussed in greater detail in the following subsections. Figure 3.3.2 shows the location of the six 201 Planning Areas along the North Carolina coast.


CURRITUCK SOUND
CURRITUCK
COROLLA
DARE BEACHES COMPLEX
CURRITUCK BANKS
KILL DEVIL HILLS
ALBEMARLE SOUND
CHOWAN RIVER
ALLIGATOR RIVER
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
HATTERAS ISLAND
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
CARTERET COUNTY
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
TOPSAIL/SURF CITY
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
SOUTHEASTERN BRUNSWICK COUNTY
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH
SOUTHWESTERN BRUNSWICK COUNTY

LEGEND

Figure 3.3.2 201 Location Map

SECONDARY TREATMENT FACILITIES WITH OCEAN OUTFALL PROPOSED FOR DARE COUNTY INCLUDING DEVELOPED AREAS ON ROANOKE AND BODIE ISLANDS

The selected alternative developed by the 201 Facilities Plan includes a collection system to service most of Roanoke Island and the barrier island beaches. The regional treatment facilities will be located at Nags Head and will provide secondary treatment with a design flow capacity of 13,644 m^3/d (3.6 mgd). Treated effluent is proposed to be disposed via an ocean outfall.

The collection and interceptor system will include major wastewater pumping stations with the main interceptor located along Bodie Island. The areas to be served are those with existing needs and/or those areas having a high priority to receive the full range of public services, according to the Dare County Coastal Area Management Act Land Use Plan. Service areas include Kill Devil Hills, Nags Head, Whalebone-South Bodie Island, Manteo and Wanchese. A subaqueous forcemain, joining the main interceptor in the vicinity of Whalebone Junction, will transport the wastewater from the Roanoke Island service areas (Manteo and Wanchese). This subaqueous force main alignment will parallel the existing U.S. Highway 64 and 264 Bridge and Causeway that spans Roanoke Sound.

The regional treatment facilities will be located on Bodie Island at Nags Head on land owned by the town near the existing water treatment plant. The existing secondary type circular concrete wastewater treatment facilities serving the town of Manteo are to be abandoned and its discharge removed from Shallowbag Bay.

The proposed facilities will be a modular construction and will provide secondary treatment with a design flow capacity of 13,644 m^3/d (3.6 mgd). The process components include the following:

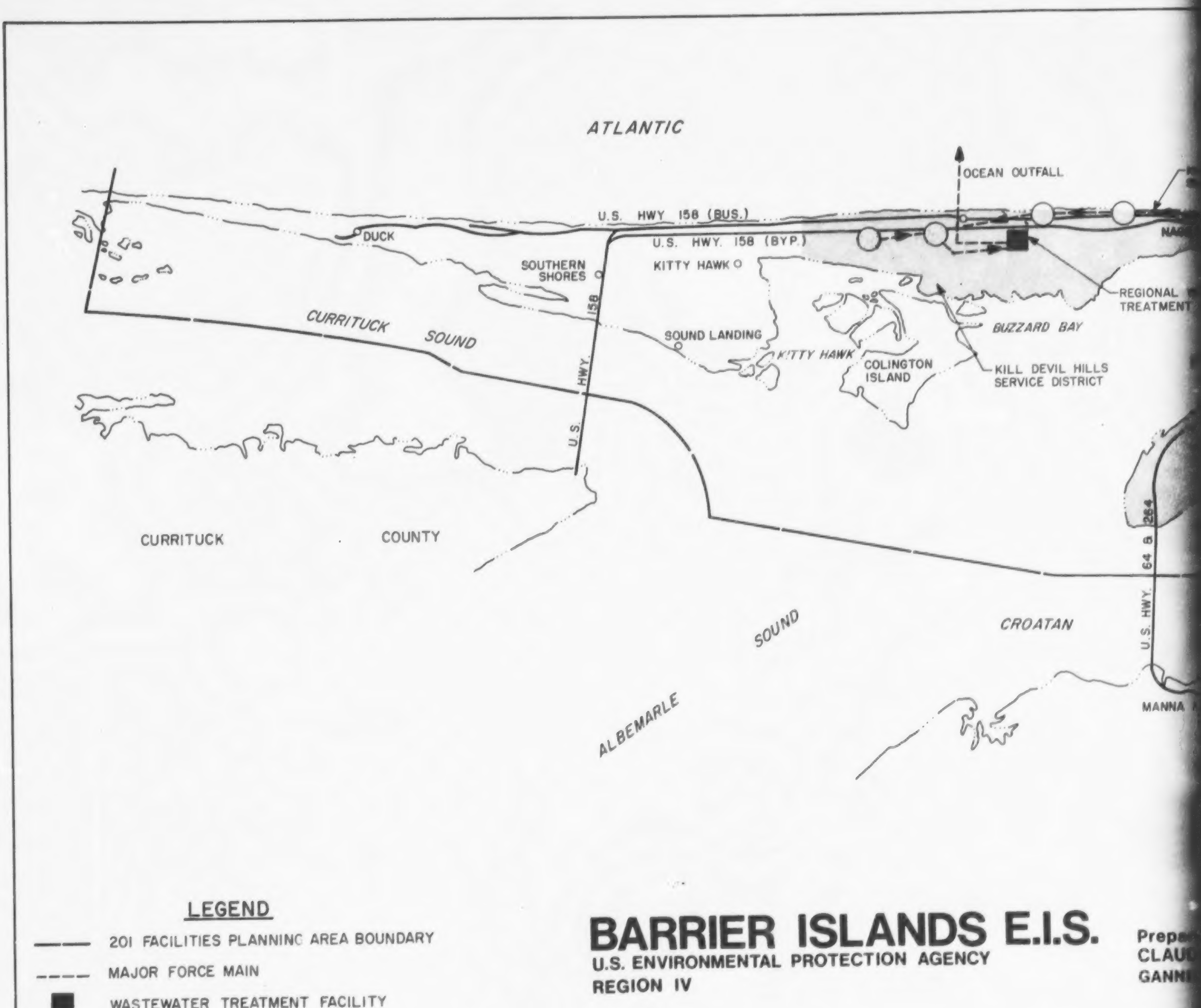
Preliminary treatment facilities
Dual oxidation ditches
Dual secondary clarifiers
Chlorination/dechlorination facilities
Post aeration
Effluent pumping with ultimate disposal via ocean outfall
Sludge handling and disposal facilities
Administration, laboratory, control, garage and shop facilities

Preliminary treatment consists of screening and grit removal, flow measurement, and automatic sampling. The dual oxidation ditches are to operate on the extended aeration modification of the activated sludge process. Each ditch will be 448 feet by 94 feet with four 30 HP drive rotors for the required oxygenation and mixing. Sludge handling will be by aerobic digestion and dewatering on sand drying beds. Final disposal will be at the

3.3.2.1 Continued

Dare County Sanitary Landfill at Manteo by contracted hauling.

The submarine outfall will include a multiport diffuser system and is presently proposed to be one mile off shore in the Atlantic Ocean. The 201 Facilities Plan proposal calls for a marine site survey to be conducted according to USEPA interim regulations on ocean outfalls in order to determine proper design. Figure 3.3.2.1 displays the treatment facility's location, interceptor alignment, service areas and the discharge location.


ATLANTIC
OCEAN OUTFALL
U.S. HWY 158 (BUS.)
U.S. HWY. 158 (BYP.)
DUCK
NAG
SOUTHERN SHORES
KITTY HAWK
REGIONAL
TREATMENT
CURRITUCK SOUND
U.S. HWY. 158
SOUND LANDING
KITTY HAWK
BUZZARD BAY
COLINGTON ISLAND
KILL DEVIL HILLS SERVICE DISTRICT
CURRITUCK COUNTY
U.S. HWY. 64 & 264
ALBEMARLE SOUND
CROATAN
MANNA
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
WASTEWATER TREATMENT FACILITY
PUMPING STATION
SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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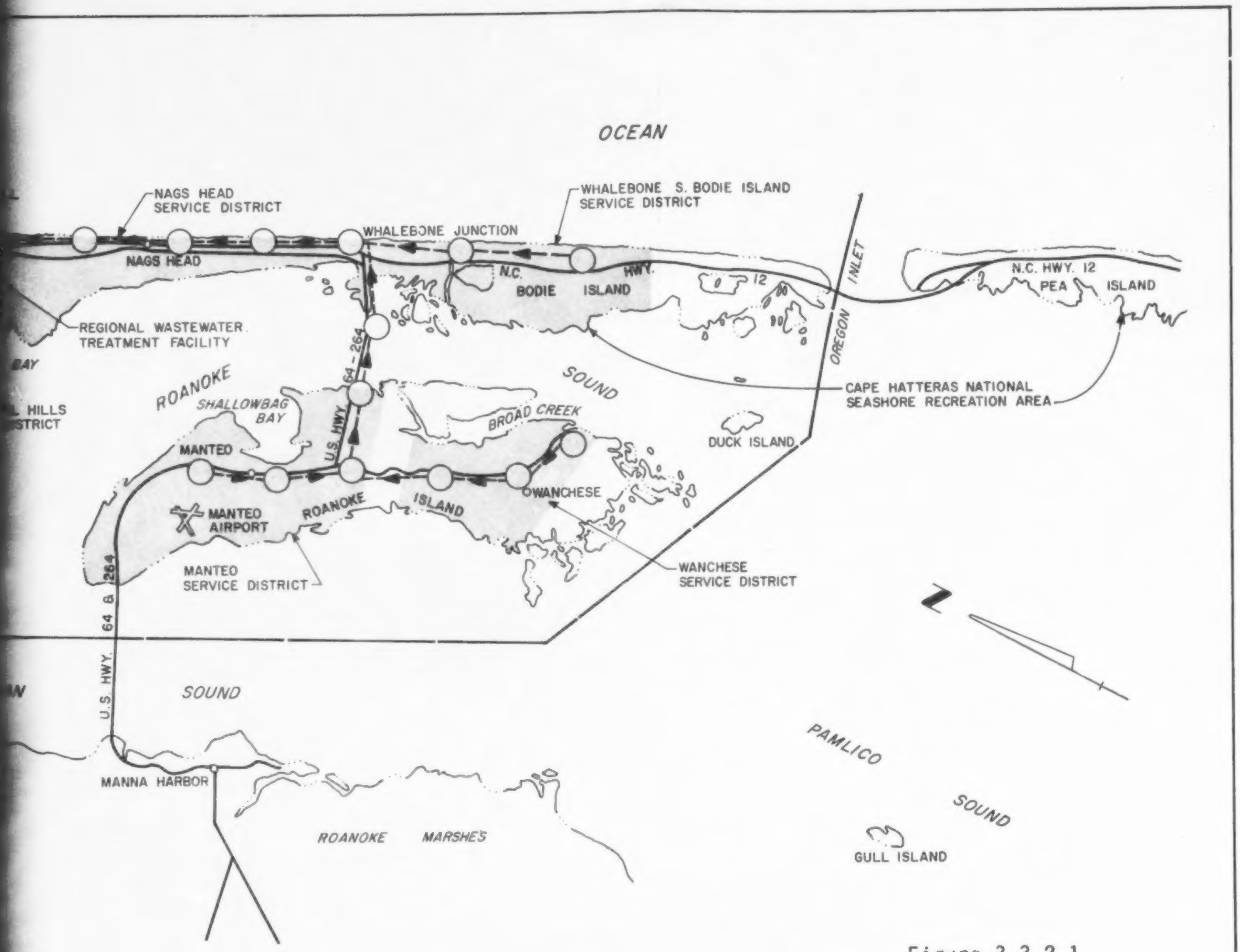

OCEAN
NAGS HEAD SERVICE DISTRICT
WHALEBONE S. BODIE ISLAND SERVICE DISTRICT
WHALEBONE JUNCTION
NAGS HEAD
N.C.
BODIE ISLAND
HWY.
12
N.C. HWY. 12
PEA ISLAND
OREGON INLET
REGIONAL WASTEWATER TREATMENT FACILITY
BAY
ROANOKE
SHALLOWBAG BAY
HILLS
STRICT
U.S. HWY. 64-264
SOUND
BROAD CREEK
CAPE HATTERAS NATIONAL SEASHORE RECREATION AREA
DUCK ISLAND
MANTEO
WANCHESE
MANTEO AIRPORT
ROANOKE ISLAND
MANTEO SERVICE DISTRICT
WANCHESE SERVICE DISTRICT
U.S. HWY. 64 & 264
N
SOUND
PAMLICO SOUND
MANNA HARBOR
ROANOKE MARSHES
GULL ISLAND

Figure 3.3.2.1

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY AT NAGS HEAD WITH EFFLUENT
DISCHARGE TO ATLANTIC OCEAN

201 FACILITIES PLANNING AREA
DARE COUNTY COMPLEX

1 0 1 2 3 4
SCALE IN MILES

S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

3-37a

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.3 Wastewater Systems

3.3.2 201 Facilities Plans Selected Alternatives

3.3.2.2 Hatteras Island

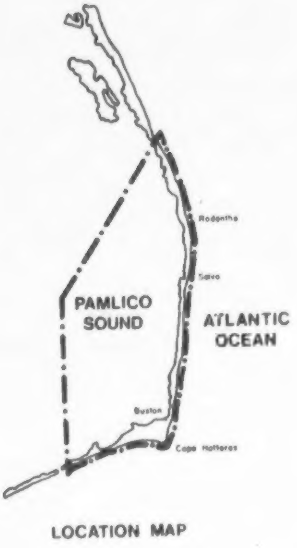
HATTERAS ISLAND 201 PLAN SELECTS NO FEDERAL ACTION ALTERNATIVE

Excessive user charge costs for implementing the proposed structural alternative (two regional treatment and disposal systems) have resulted in a decision to retain current wastewater management systems.

The wastewater planning area was subdivided into two service districts. The first coincides with the public water supply district boundaries, the Cape Hatteras Water Association (CHWA) service area, comprising the villages of Avon, Buxton, Frisco and Hatteras. The second service area contains the villages of Rodanthe, Waves and Salvo.

Three similar structural alternatives were considered for the CHWA area and two for the Rodanthe/Waves/Salvo (RWS) area. Wastewater would be collected and transported by conventional gravity flow sewers and pump stations. Treatment included grit removal, equalization, activated sludge treatment, filtration and disinfection. Sludge would be aerobically digested and dewatered mechanically in the CHWA area and dewatered on drying beds in the RWS area. Dried sludge would then be transported to the county landfill on Roanoke Island. Effluent would be disposed by rotary distributors.

The least costly alternative for the CHWA area involved a regional system with treatment and disposal at Avon in Buxton Woods (see Figure 3.3.2.2). The least costly alternative for the RWS area was a regional system with treatment and disposal at a site between Rodanthe and Waves. The 201 consultants have recommended that no action be taken on the proposed structural alternatives because user charges are too high to be affordable. Even with additional collector system grants from FmHA, annual user charges for a typical household would approach $402.48 for the CHWA area and $336.00 for the RWS area.


Rodanthe
Salvo
PAMLICO SOUND
ATLANTIC OCEAN
Buxton
Cape Hatteras
LOCATION MAP

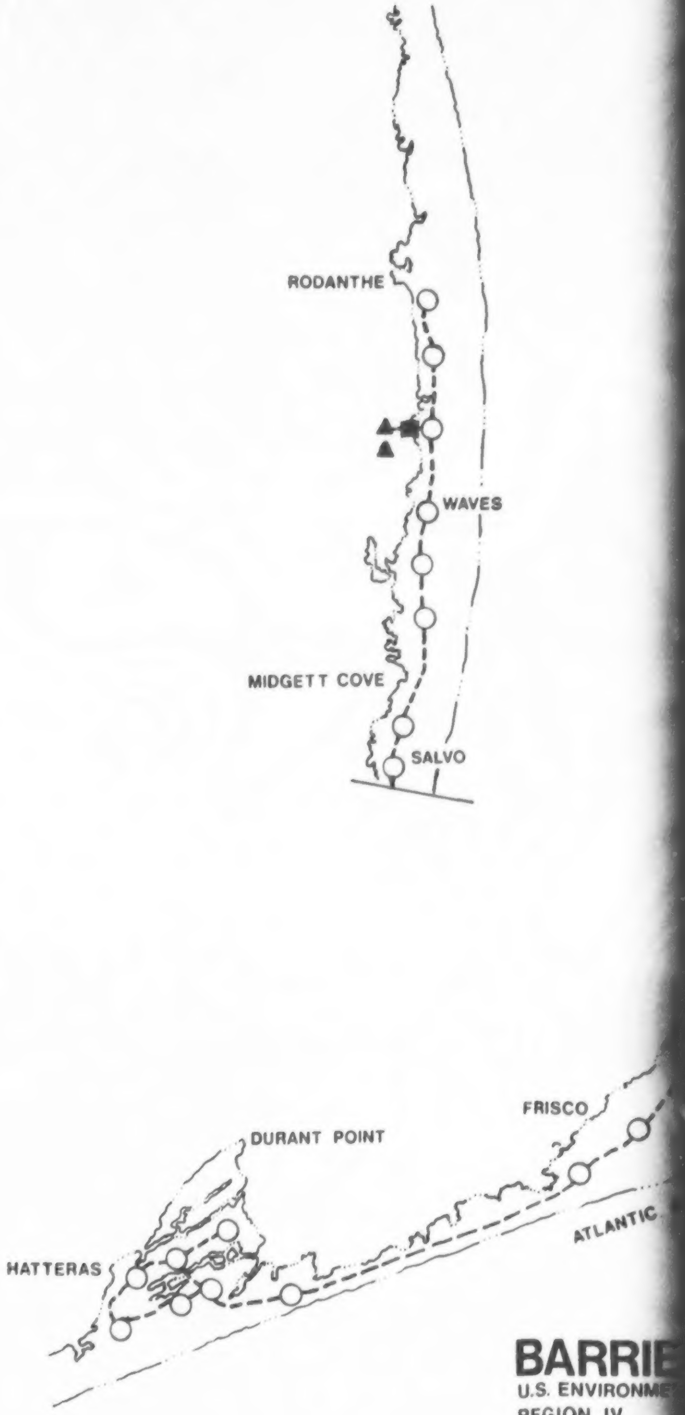

RODANTHE
WAVES
MIDGETT COVE
SALVO
FRISCO
DURANT POINT
HATTERAS
ATLANTIC

Figure 3.3.2.2

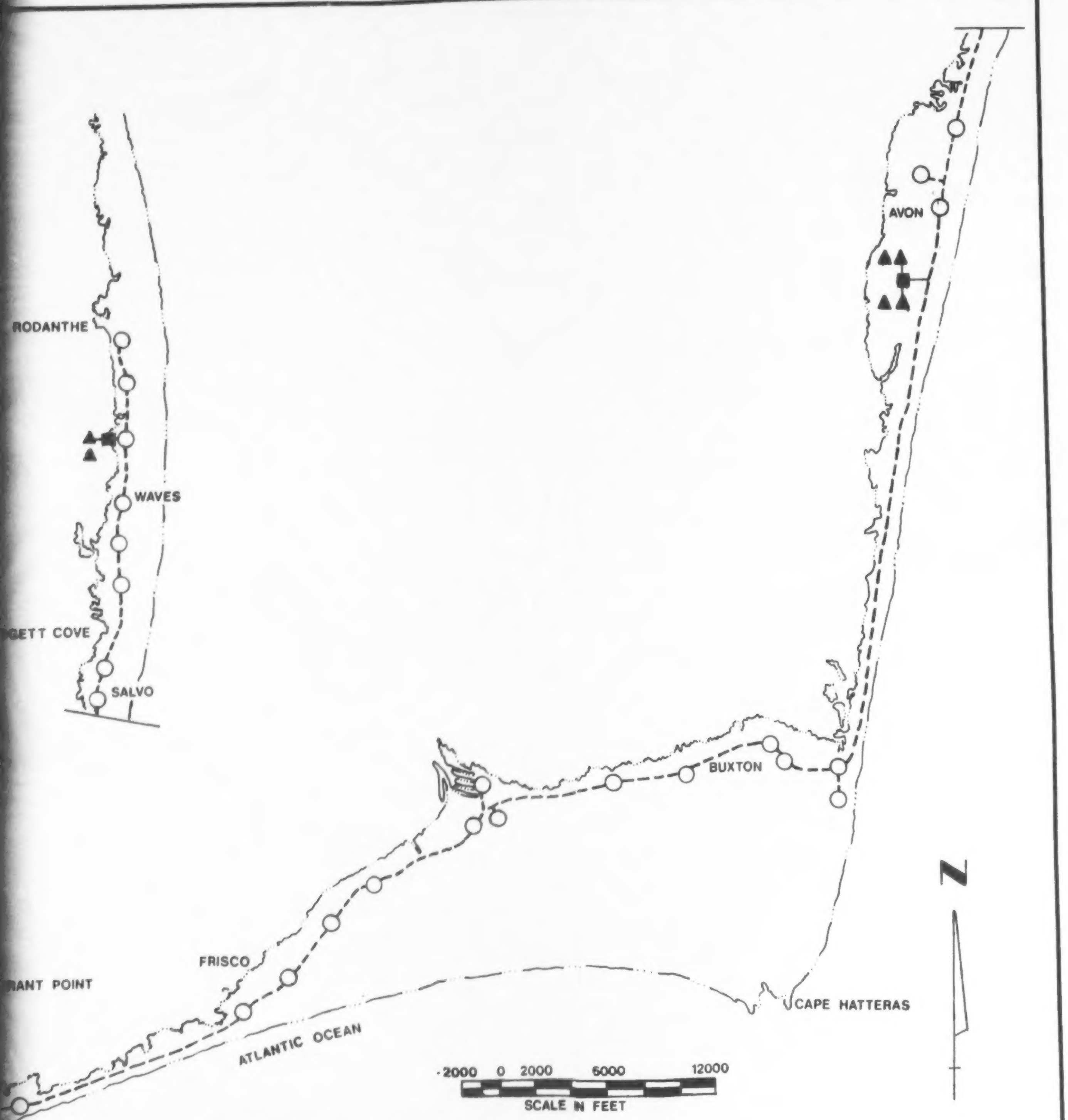
201 FACILITIES PLANNING AREA
HATTERAS ISLAND

NOTE: Not All Pumping Stations Are Shown

LEGEND

- ---- MAJOR FORCE MAIN
- ■ WASTEWATER TREATMENT FACILITY
- ○ PUMPING STATION
- ▲ LAND APPLICATION

BARRIE
U.S. ENVIRONME
REGION IV


RODANTHE
WAVES
GETT COVE
SALVO
AVON
BUXTON
FRISCO
ANT POINT
CAPE HATTERAS
ATLANTIC OCEAN
N
-2000 0 2000 6000 12000
SCALE IN FEET

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

3-39a

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.3 Wastewater Systems

3.3.2 201 Facilities Plans Selected Alternatives

3.3.2.3 Carteret County Complex

THREE SEPARATE TREATMENT SYSTEMS WITH EFFLUENT DISPOSAL VIA OCEAN OUTFALL, DISCHARGE INTO TAYLOR'S CREEK, AND DISCHARGE INTO NEWPORT RIVER ARE PROPOSED FOR FIVE SERVICE AREAS

The selected alternative involves three separate treatment and disposal systems. One system providing secondary treatment will service the East Bogue Banks area. Effluent disposal will be via an ocean outfall. The second system will service Beaufort using the existing treatment facilities with additions to upgrade so that tertiary treatment will be provided. Effluent will continue to be discharged into Taylor's Creek. The third system will service both Newport and Morehead City using the existing treatment facility at Morehead City. The existing facilities are proposed to be upgraded to provide tertiary treatment. Effluent disposal will be discharged into the Newport River.

The new treatment facilities located at Pine Knoll Shores will serve the areas of Atlantic Beach and Pine Knoll Shores of East Bogue Banks providing secondary treatment for a design flow of 3868 m^3/d (1.02 mgd). The proposed facilities will be an oxidation ditch system with ultimate effluent disposal to the Atlantic Ocean. The process components include the following:

Preliminary treatment and flow monitoring
Small oxidation ditch with single clarifier
Large oxidation ditch with dual clarifiers
Chlorination facilities and effluent monitoring
Sludge handling and disposal facilities

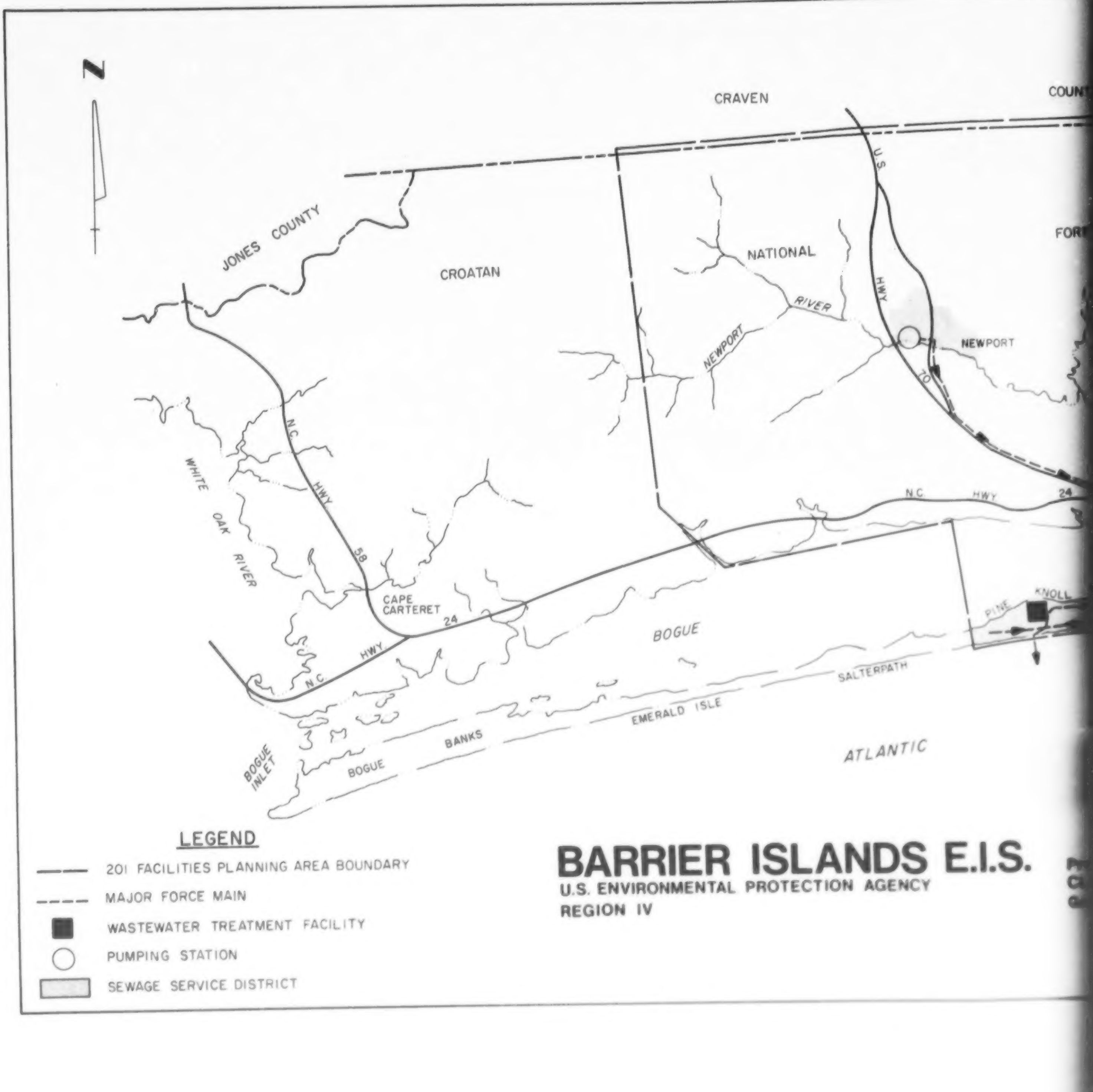
Two oxidation ditches were proposed to handle the extreme variation in the seasonal flow rates. The excess activated sludge and screening and grit removals will be aerobically digested prior to drying on sand beds with final disposal to a sanitary landfill. The effluent disposal to the Atlantic Ocean will be via an ocean outfall that presently is proposed to be one mile offshore. The 201 Facilities Plan calls for the completion of a Marine Site Survey in order to define the exact location, length, etc. of the outfall and to provide specific design data on the pipeline and its diffuser section.

The treatment facilities to serve the Beaufort area will include the existing wastewater treatment works located northeast of the town limits. These existing facilities will be upgraded to provide advanced treatment at a design flow rate of 2843 m^3/d (0.75 mgd). Additions will include dual multi-media gravity filters with manual air scour, a stormwater retention pond and 1161 m^2 (12,250 ft^2) of new sludge drying beds. Effluent disposal will utilize the existing discharge outfall to Taylor's Creek.

3.3.2.3 Continued

The treatment facilities to serve the Newport and Morehead City areas will include the existing facilities at the Morehead City Sewage Treatment Plant. Newport's existing sewage treatment plant will be abandoned. The Morehead City facilities will be upgraded to provide advanced treatment at a design flow rate of 6443 m^3/d (1.7 mgd). Upgrading will involve major renovation or replacement of some existing equipment such as pumps and motors. Additions include a self-cleaning, aerated grit removal and screening system placed at the new lift station for preliminary treatment, a new primary sedimentation unit to aid the existing unit, dual-media gravity filters, chlorination facilities and additional laboratory space. The existing anaerobic digester will be converted to an aerobic digester for sludge handling. Effluent disposal is proposed to be changed from the existing discharge to Calico Creek to a new discharge to the SC water quality zone of the Newport River near of the Morehead City-Beaufort Highway Bridge (U.S. Hwy. 70). Construction of a new effluent pumping station and force main will be required to transport the effluent to the outfall which will include a subaqueous diffuser.

The three treatment schemes are illustrated in Figure 3.3.2.3 which displays the treatment facilities' locations, major interceptor alignments, service areas and discharge locations.


N
CRAVEN
COUNT
JONES COUNTY
CROATAN
NATIONAL
NEWPORT RIVER
FOR
U.S. HWY 70
NEWPORT
N.C. HWY 58
WHITE OAK RIVER
N.C. HWY 24
CAPE CARTERET
BOGUE
PINE KNOLL
SALTERPATH
EMERALD ISLE
BOGUE BANKS
BOGUE INLET
ATLANTIC
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
WASTEWATER TREATMENT FACILITY
PUMPING STATION
SEWAGE SERVICE DISTRICT
BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

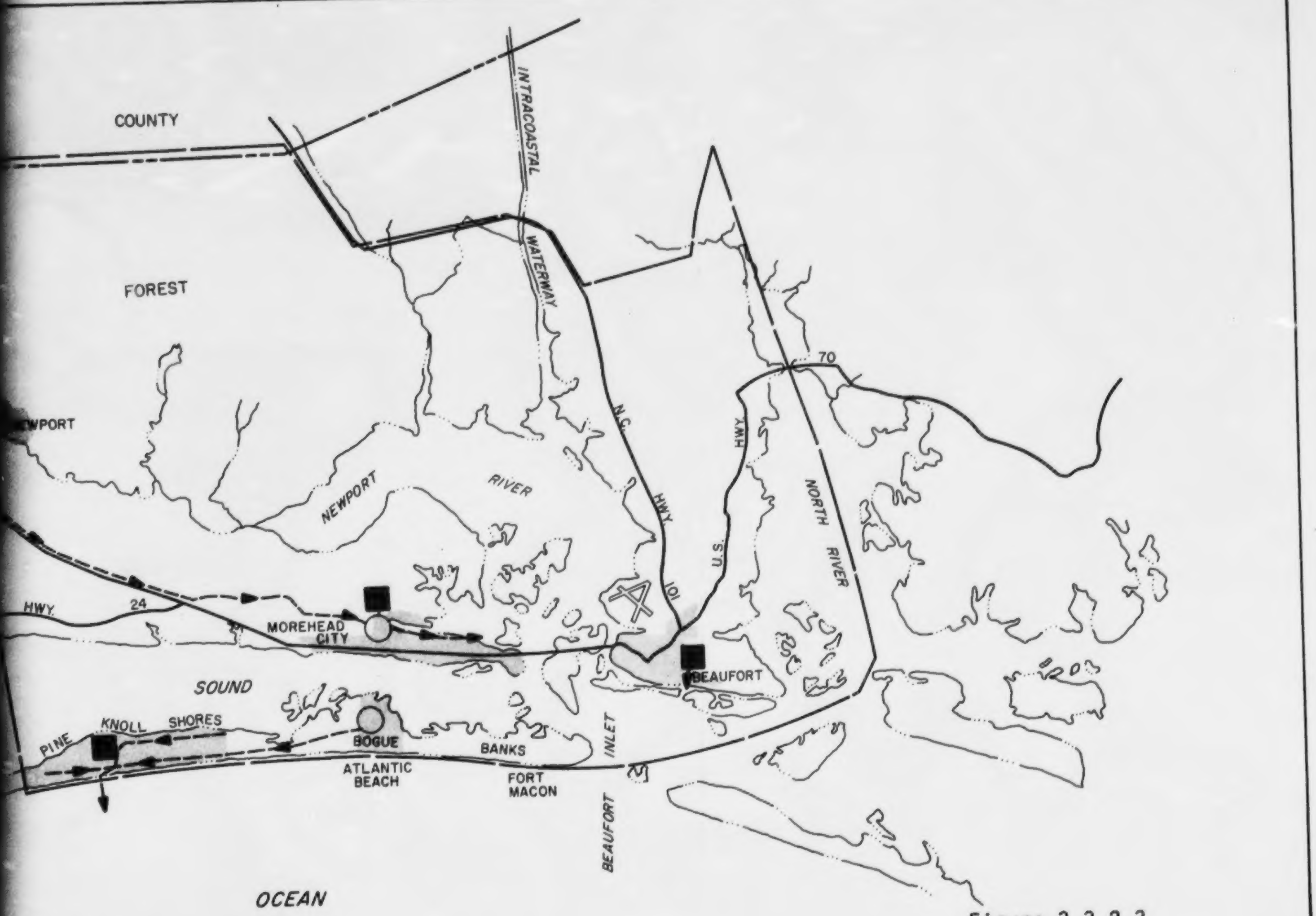

COUNTY
FOREST
INTRACOASTAL
WATERWAY
NEWPORT
NEWPORT
RIVER
N.C.
HWY.
101
U.S.
HWY
70
NORTH
RIVER
HWY.
24
MOREHEAD
CITY
BEAUFORT
SOUND
PINE
KNOLL
SHORES
BOGUE
BANKS
ATLANTIC
BEACH
FORT
MACON
BEAUFORT
INLET
OCEAN

Figure 3.3.2.3

REGIONAL ALTERNATIVE PLAN
3 SEPARATE TREATMENT FACILITIES WITH
EFFLUENT DISCHARGE TO ATLANTIC OCEAN,
TAYLORS CREEK, AND NEWPORT RIVER

E.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

201 FACILITIES PLANNING AREA
CARTERET COUNTY COMPLEX

1 0 1 2 3 4
SCALE IN MILES

3.3.2.4 Topsail/Surf City

PRESSURE/GRAVITY COLLECTION, STABILIZATION LAGOON TREATMENT AND LAND APPLICATION DISPOSAL ARE PROPOSED FOR ALL DEVELOPED AREAS OF TOPSAIL ISLAND

The selected alternative developed by the 201 Facilities Plan includes construction of a collection/interceptor system to service the developed areas on Topsail Island. The treatment facilities proposed include a stabilization lagoon and a spray irrigation system on a site west of Holly Ridge leased from the International Paper Company. The design flow of these facilities is proposed to be 8717 m^3/d (2.3 mgd.

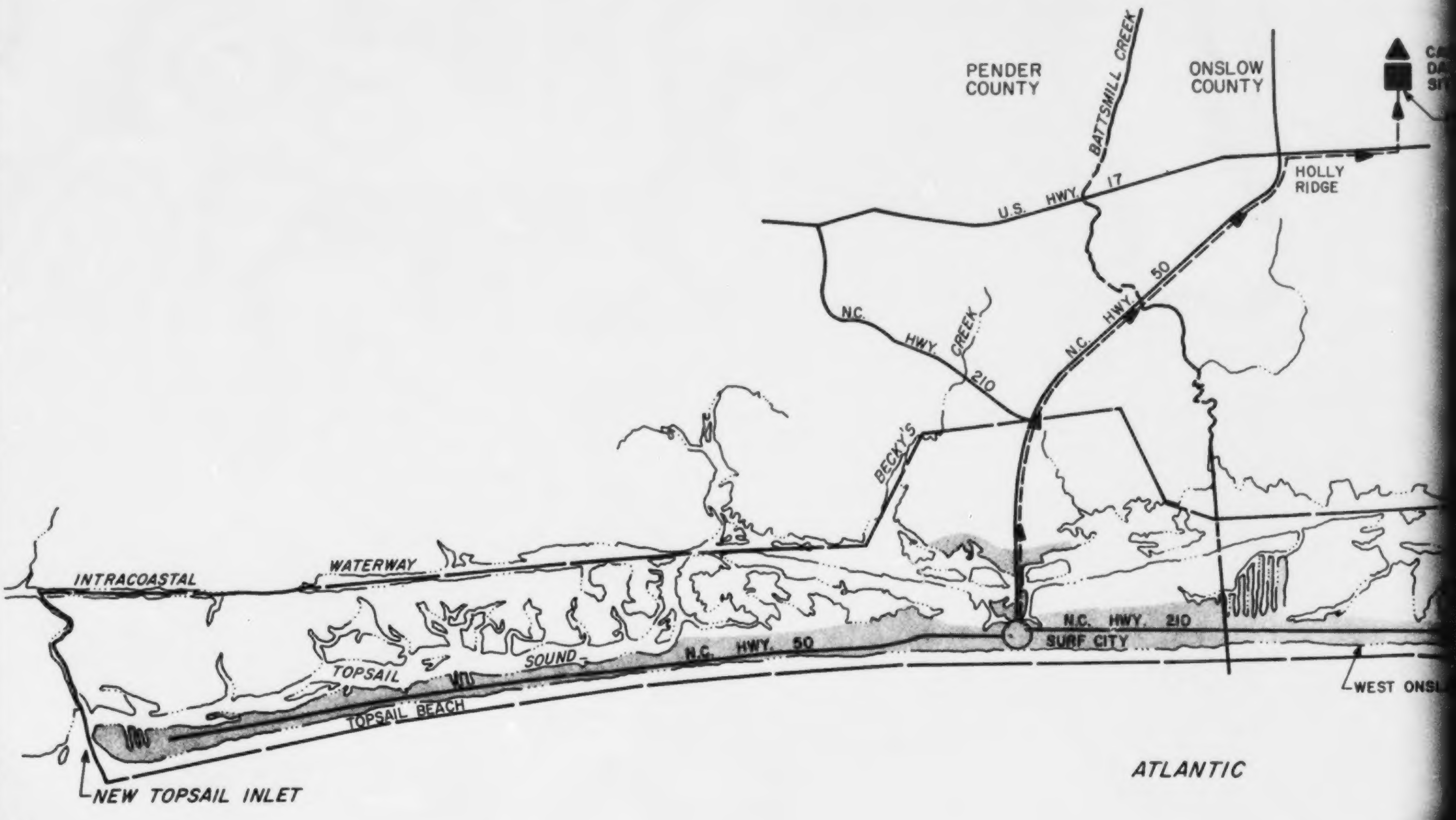
No wastewater collection systems exist within the planning area. The 201 Facilities Plan proposed the construction of a combination pressure/gravity system to collect all wastewater flows. The pressure sewers were designed around a grinder pump alternative for service subareas located away from the main interceptor. The preliminary design of the system consists of a series of gravity sewer subsystems which run in a linear fashion along the oceanfront.

Both the gravity sewer system and the pressure sewer system will have a complementary interceptor system consisting of pump stations and force mains necessary to pump the collected wastewaters to the treatment facilities west of Holly Ridge. The interceptor system will include the construction of a subaqueous force main to serve as a waterway crossing to transport flows from Topsail Island to the mainland. This crossing will be located adjacent to the existing highway (N.C. Route 50-210) bridge at Surf City.

Wastewater will be treated by a stabilization lagoon treatment system on a site at Camp Davis west of the town of Holly Ridge. The treatment system, designed to handle a flow of 8717 m^3/d (2.3 mgd) will include the following components:

Preliminary treatment facilities
Stabilization pond (lagoon)
Storage reservoir
Chlorination facilities
Pumping facilities

The treated effluent will then be disposed by land application via a solid set spray irrigation system on a pine forest site near the treatment facilities. The site is approximately 100 ha (250 ac) in an isolated rural area and will be leased from the International Paper Company, Inc. Sludge will be collected and disposed at a sanitary landfill. Figure 3.3.2.4 displays the treatment facility's location, interceptor alignment, land application site, and service areas.


PENDER COUNTY
BATTSMILL CREEK
ONSLOW COUNTY
CA
DA
SI
HOLLY RIDGE
U.S. HWY. 17
N.C. HWY 50
N.C. HWY CREEK 210
BECKY'S
INTRACOASTAL
WATERWAY
TOPSAIL
SOUND
N.C. HWY. 50
N.C. HWY. 210
SURF CITY
TOPSAIL BEACH
WEST ONSL
ATLANTIC
NEW TOPSAIL INLET

LEGEND

— —	201 FACILITIES PLANNING AREA
- - - -	MAJOR FORCE MAIN
■	WASTEWATER TREATMENT FACILITY
○	PUMPING STATION
▲	LAND APPLICATION
▨	SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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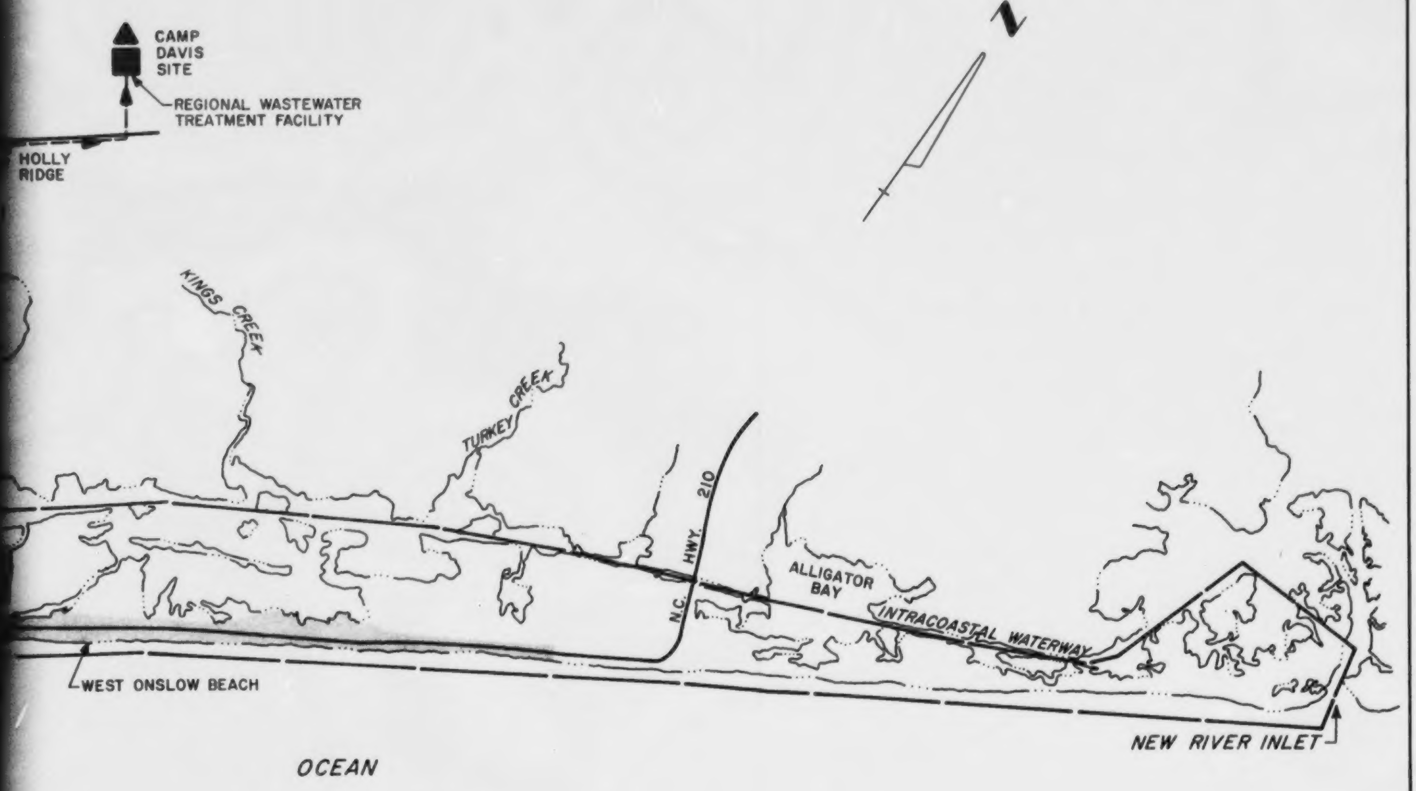

CAMP DAVIS SITE
REGIONAL WASTEWATER TREATMENT FACILITY
HOLLY RIDGE
N
KINGS CREEK
TURKEY CREEK
N.C. HWY. 210
ALLIGATOR BAY
INTRACOASTAL WATERWAY
WEST ONSLOW BEACH
NEW RIVER INLET
OCEAN

S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Figure 3.3.2.4

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY LOCATED AT CAMP DAVIS SITE
WITH LAND APPLICATION OF EFFLUENT

201 FACILITIES PLANNING AREA
TOPSAIL-SURF CITY

6,000 0 6,000 12,000
SCALE IN FEET

3.3.2.5 Southeastern Brunswick County

EXTENSION OF EXISTING COLLECTION SYSTEM, SECONDARY TREATMENT AND EFFLUENT DISCHARGE TO THE CAPE FEAR RIVER IS PROPOSED

The 201 Facilities Plan for the Southeastern Brunswick County planning area proposed extending the existing collection system, which presently serves only the town of Southport, to include parts of Oak Island and some rural areas outside of Southport's boundaries. The regional treatment facilities are to be located near Southport and will provide secondary treatment for a design flow of 7845 m^3/d (2.07 mgd). The treated effluent will then be discharged to the Cape Fear River.

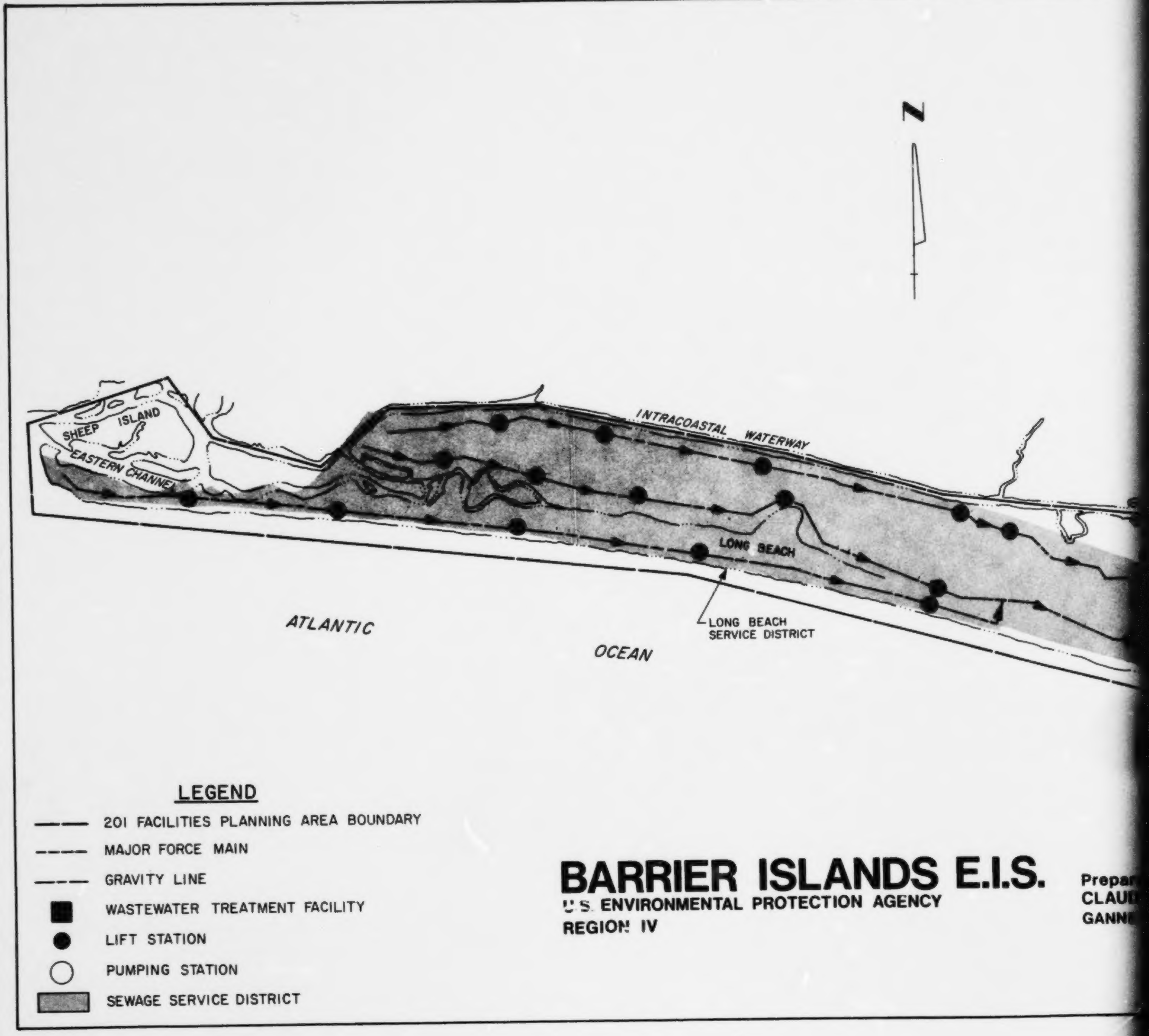
The collection/interceptor system proposed to convey wastewaters to the centralized treatment facilities will service areas that were identified as in need based on projected development for the year 1990. The existing system in Southport will be included. Extensions to the existing system and construction of new facilities (mainly on Oak Island) will, after a phased construction program, encompass all of Southport, Yaupon Beach, Caswell Beach, parts of the community of Long Beach and unincorporated rural areas in Brunswick County. The interceptor system will include force mains with a system of lift stations and pump stations.

The regional treatment facilities will be located on a 10 ha (25 ac) site northeast of Southport and southwest of the Pfizer Chemical Plant. The existing secondary treatment facilities serving Southport will be abandoned. The proposed facilities will consist of an oxidation ditch treatment process that provides secondary treatment for a design flow of 7845 m^3/d (2.07 mgd). The process components include the following:

Preliminary treatment facilities
Oxidation ditch
Clarifiers (2)
Chlorination facilities
Gravity sludge thickener unit
Sludge drying beds (8)

The preliminary treatment facilities consist of screening and grit removal. The waste sludge from the clarifiers is thickened and dried. The final disposal of the sludge cake is proposed to be off-site but presently there is no sanitary landfill site in the area.

The treated effluent is to be discharged via a diffused outfall system to the main channel of the Cape Fear River. Figure 3.3.2.5 displays the treatment facility's location, interceptor alignment, service areas, and discharge location for the proposed plan.


SHEEP ISLAND
EASTERN CHANNEL
INTRACOASTAL WATERWAY
LONG BEACH
LONG BEACH SERVICE DISTRICT
ATLANTIC
OCEAN
N
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
GRAVITY LINE
WASTEWATER TREATMENT FACILITY
LIFT STATION
PUMPING STATION
SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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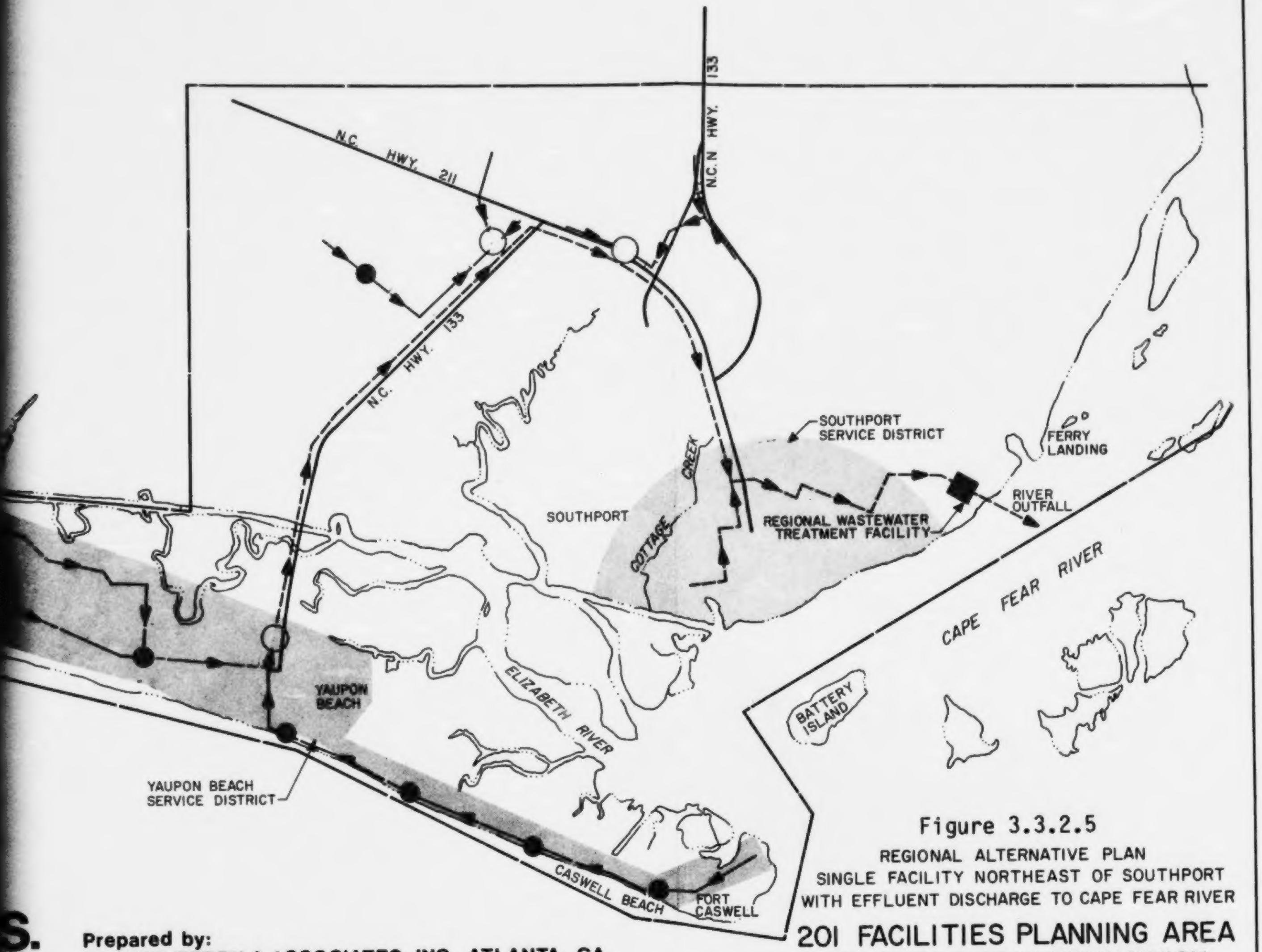

N.C. HWY. 211
N.C.N HWY. 133
N.C. HWY. 133
SOUTHPORT SERVICE DISTRICT
FERRY LANDING
SOUTHPORT
COTTAGE CREEK
REGIONAL WASTEWATER TREATMENT FACILITY
RIVER OUTFALL
CAPE FEAR RIVER
BATTERY ISLAND
ELIZABETH RIVER
YAUPON BEACH
YAUPON BEACH SERVICE DISTRICT
CASWELL BEACH
FORT CASWELL
4,000
0
4,000
8,000
SCALE IN FEET

Figure 3.3.2.5

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY NORTHEAST OF SOUTHPORT
WITH EFFLUENT DISCHARGE TO CAPE FEAR RIVER

**201 FACILITIES PLANNING AREA
SOUTHEASTERN BRUNSWICK
COUNTY**

S.

**Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.**

FIVE LOCALIZED TREATMENT FACILITIES WITH LAND APPLICATION BY SPRAY IRRIGATION PROPOSED FOR THE SOUTHWEST BRUNSWICK COUNTY PLANNING AREA

The selected alternative developed by the 201 Facilities Plan includes construction of five separate collection systems, secondary treatment facilities and sites for land application by spray irrigation. These localized systems will serve the areas of Calabash, Sunset Beach, Holden Beach, Ocean Isle Beach, and Shallotte.

The alternative proposed by the 201 Facilities Plan calls for each of the five communities to have its own treatment system for handling the wastewater flows collected and transported by its individual collection/interceptor systems. Each scheme includes coarse screening facilities for preliminary treatment followed by a lagoon. The treated effluent is proposed to be chlorinated prior to land application via a solid set spray irrigation system. Each site selected will provide a buffer zone of 61 m (200 ft) to protect nearby communities from adverse impacts. The chlorination facilities for each scheme are sized to handle the peak summer flow rates of each service area.

Calabash is to have a main pump station with a pumping capacity of 417 m^3/d (0.11 mgd) located near the intersection of the Highway SR 1163 and the town limits. The force main is to pump the flow to a 4 ha (10 ac) site near the 20 ha (50 ac) designated for spray irrigation.

Sunset Beach's collection/interceptor system is to include a main pumping station and a booster pumping station that will transport the flow to the treatment site. The main pumping station has a capacity of 569 m^3/d (0.15 mgd) and is located near Highway SR 1172 and the town limits. The lagoon treatment facility is located on a 2 ha (5 ac) site adjacent to a 24 ha (60 ac) land application site.

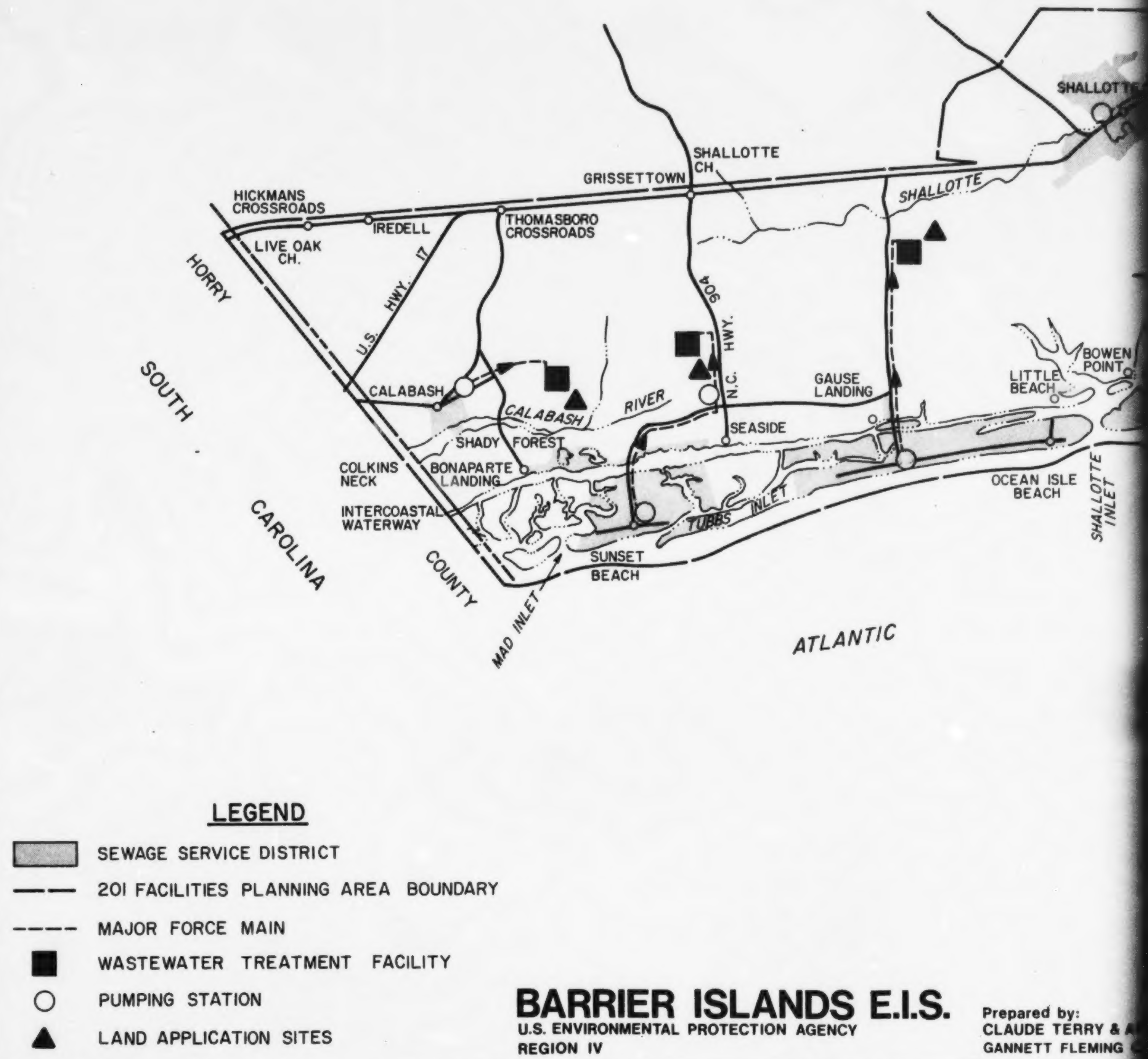
Holden Beach is also proposed to have a main pumping station and a booster pumping station. The main pumping station is to be located near the intersection of High way NC 130 and the town limits and will transport flows of 1516 m^3/d (0.4 mgd) to the treatment site which is to be north of the area on the mainland. The lagoon treatment system will be located on a 4.5 ha (11.2 ac) site while the land application site will involve 38 ha (90 ac).

Ocean Isle is proposed to have one main pumping station to transport the collected flows at a design capacity of 1137 m^3/d (0.3mgd). The station is located near the intersection of Highway NC 904n and the town's limits and will route the flow through the force main to the treatment facilities to be located to the north on the mainland. The lagoon treatment system will require 3.6 ha (8.8 ac) and the land application site 38.5 ha (95 ac).

Shallotte is proposed to have one pumping station that is to transport

3.3.2.6 Continued

the flows via a force main to an area northeast of the town that is the proposed site for the treatment facilities. The pump station is to have a design flow capacity of 1127 m^3/d (0.35 mgd) and is located near the southeastern town limits and the Shallotte River. The lagoon treatment system is to be located on a 6.5 ha (16 ac) site. The land application site contains 42.5 ha (105 ac). The chlorination facilities for this particular treatment scheme is designed to handle a flow equal to the projected peak summer wastewater flow plus 190 m^3/d (.05 mgd). The additional flow capacity is provided so that the facilities can handle the drainage of the wet weather storage basin during the summer. Unlike the other service areas, Shallotte is required to have a basin which will handle the flows generated by wet weather conditions.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HORRY
U.S. HWY. 17
N.C. HWY. 904
SOUTH
BOWEN POINT
LITTLE BEACH
GAUSE LANDING
CALABASH
CALABASH
RIVER
SEASIDE
SHADY FOREST
COLKINS NECK
BONAPARTE LANDING
OCEAN ISLE BEACH
SHALLOTTE INLET
INTERCOASTAL WATERWAY
CAROLINA
TUBBS INLET
SUNSET BEACH
COUNTY
MAD INLET
ATLANTIC
LEGEND
▨ SEWAGE SERVICE DISTRICT
— — 201 FACILITIES PLANNING AREA BOUNDARY
- - - - MAJOR FORCE MAIN
■ WASTEWATER TREATMENT FACILITY
○ PUMPING STATION
▲ LAND APPLICATION SITES

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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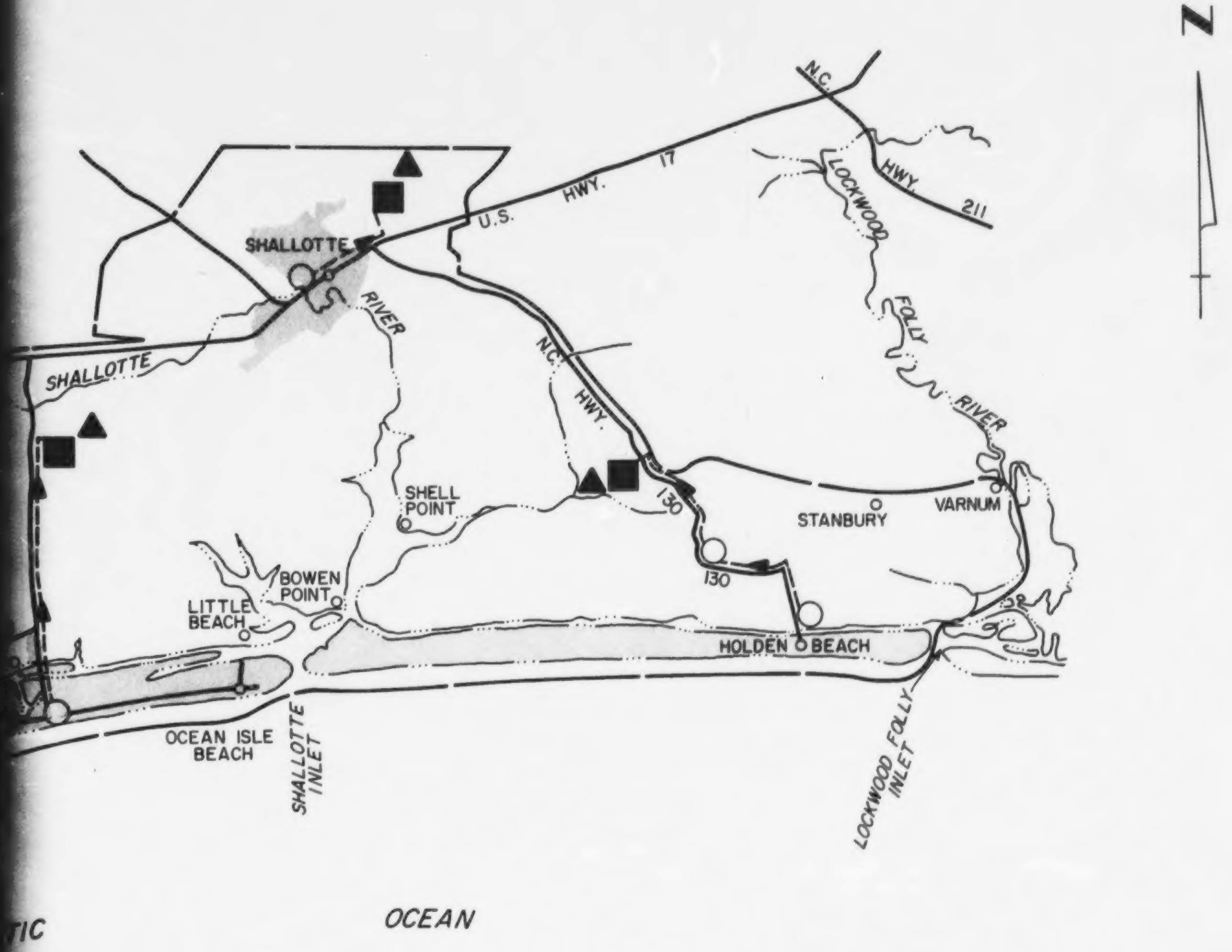
CLAUDE TERRY & A
GANNETT FLEMING C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VARNUM
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HOLDEN BEACH
58
OCEAN ISLE BEACH
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LOCKWOOD FOLLY INLET
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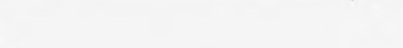
Figure 3.3.2.6
REGIONAL ALTERNATIVE PLAN
FIVE LOCAL TREATMENT FACILITIES WITH
LAND APPLICATION SITES FOR
SPRAY IRRIGATION OF EFFLUENT

201 FACILITIES PLANNING AREA
SOUTHWEST BRUNSWICK COUNTY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SCALE IN MILES

E.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

3-49a

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.3 Wastewater Systems

3.3.3 Siting Criteria for Conventional/Alternative On-Site Systems

ON-LOT SYSTEMS SUITABLE FOR BARRIER ISLANDS REQUIRE SITE SPECIFIC SOILS DATA

For some areas of the barrier islands, soils limit the use of conventional on-site treatment/disposal methods. Alternative on-site methods are necessary in some soils to assure effluents are properly treated before entering surface waters or groundwater. Criteria include soils, depth to groundwater and density of development.

Individual on-site disposal systems consisting of conventional septic tanks and soil absorption systems are in widespread use on the barrier islands. The limited number of centralized collection and treatment systems on the islands has necessitated the use of these systems, often times in marginal natural and man-made fill areas.

All subsurface disposal systems must be permitted prior to construction. Permit applications must contain information regarding individual system suitability, including available space and the results of investigations by qualified professionals made during the wettest time of the year. These investigations include consideration of percolation characteristics, soil profiles, water table elevations, flood history and the performance record for individual systems in adjacent areas. The laws and rules for soil absorption systems are discussed in Section 3.6.3.1.

Septic tank and absorption field construction standards are detailed in the North Carolina Administrative Code Title 10. Throughout North Carolina, the design, construction and maintenance of soil absorption treatment and disposal systems is the responsibility of the individual owner, developer, installer or ultimate user of the system. Local health departments have the responsibility of verifying the proper design and installation of all septic tank-ground absorption systems. Each system is inspected, and upon meeting the basic requirements, a certificate of completion is issued which authorizes the use of the system. Numerous on-site disposal systems exist on the barrier islands, many of which are the conventional trench and bed configurations. These systems under the North Carolina Code are acceptable where soils are permeable, deep and well drained.

The general topographic setting and dynamics of the barrier islands results in the development of young, somewhat shallow and poorly developed, coarse textured soils. The physical and chemical characteristics of these soils reduces their potential for the purification of wastewater effluent. As described in Section 2.3.3, soils on the barrier islands are essentially grouped in three classifications as follows:

- Deep and well-drained sands
- Shallow and poorly drained sands

3.3.3 Continued

- Shallow to moderately deep clayey soils with a characteristic high water table.

A. R. Rubin, N.C. State University, School of Agriculture and Life Sciences, prepared a report for this EIS (Appendix 3.3.3), which describes more fully the criteria for the use of on-site wastewater treatment and disposal on the barrier islands. His report includes a discussion on the design criteria associated with potential alternatives for future systems.

Other parameters which influence operation of on-site systems include lot size, lot shaping and drainage. Lot size may be one of the more restrictive criteria as development densities on the coast continue to increase and land application continues. Early indications are that properly sited on-site wastewater treatment and disposal systems will function well with development on lots as small as .13 ha (.33 ac) but function less effectively on smaller lots.

A matrix has been developed to generalize system siting criteria and relate it to the parameters discussed in Rubin's report. The information in Table 3.3.3 does not eliminate the need for a site specific evaluation to assess the suitability of on-site wastewater treatment and disposal systems. In no way do these parameters relieve the responsibility of local health departments and representatives from the North Carolina Department of Natural Resources and Community Development from detailed site investigation.

Table 3.3.3. Suitability Criteria for On-lot Wastewater Management Facilities

Depth to Restrictive Horizon-High Water Table	Potential On-lot Wastewater Management Alternative
0" to 12"	Unsuitable for soil absorption systems
>12" to 18"	Elevated mound with loam filter material
>18" to 24"	Low pressure piping distribution system with suitable fill material
>24" to 36"	Low pressure pipe system
>36" to 48"	Conventional trench and seepage beds with placement modifications
>48"	Conventional trench and seepage beds as well as any of the above listed techniques

Source: Rubin 1981. See Appendix 3.3.3.

INCREASED DEVELOPMENT WILL REQUIRE MORE COMMUNITY FACILITIES AND SERVICES ON THE BARRIER ISLANDS

More public services and facilities will be required to meet the needs of new development and increased tourism. However, personnel complements and facilities sized to meet the demands of seasonal populations far exceed off-season demand. This creates economic problems for the expansion of public services and equitable distribution of costs among those who benefit from services.

As development and greater usage of the barrier islands continue, the demand for services and facilities will grow. The costs of increased services sized for the seasonal population may place an undue burden on the year-round population. This problem is further compounded by the large number of day users who may utilize the services provided but avoid the costs of those services by not staying overnight or eating in a restaurant. Thus, much of the service costs caused by the day and seasonal users will be borne by the property owners.

The facilities and services provided by many barrier island communities exceed the minimum recommended requirements. Police protection, rescue squads, beach maintenance services and garbage collections are expanded during the peak season to meet the additional demand.

Although some barrier island areas in Brunswick County are served by the County water system, most communities use wells that tap either the water table aquifer, or more commonly, the deeper limestone aquifer. Salt water intrusion that endangers potable water supplies is a constant concern for the island communities. Some towns obtain water from wells on the mainland.

Much of the shoreline is readily accessible to visitors, either by automobile, ferries or bridges. The bridges and causeways are under the jurisdiction of the North Carolina Department of Transportation. The highways range from scenic highways to highly developed arterials. About 130 miles of the North Carolina shoreline is held by the National Park Service in Cape Hatteras and Cape Lookout National Seashores. Oceanfront beach access is supported at the local level, along with parking facilities and dune protection, as required by the CAMA plans.

SERVICES PROVIDED BY THE TOWNS ARE EXPANDED DURING PEAK SEASON

The towns on the barrier islands are responsible for providing certain services such as police and fire protection, garbage collection and water supply. These services are expanded in the peak season to provide for a full complement of visitors. Schools, health care and solid waste management facilities are primarily county functions and are located on the mainland.

Police, water supplies and garbage collection are generally a direct responsibility of towns on the barrier islands. Schools and health care facilities are primarily county functions and are generally located on the mainland. Counties also operate landfills, and county sheriffs' offices provide supplemental police protection. Fire and rescue squad protection are performed by voluntary organizations.

Only Wrightsville Beach, Carolina Beach and Kure Beach have central wastewater treatment and disposal service in all or parts of their jurisdictions. The remainder of the barrier islands are served by on-lot disposal.

Table 3.4.1.a lists the existing services provided by barrier island communitiies. During peak season, most towns increase their police complement, the number of garbage collections, rescue squad personnel and beach maintenance services. Table 3.4.1.b quantifies community services, personnel, and facilities for selected barrier islands communities. The services represented are those most typically provided by towns on the islands. When service levels are compared to suggested minimum community standards (DeChiara and Koppelman 1969), police, fire and solid waste disposal services exceed minimum requirements. The fact that these services must be increased during the summer months to accommodate the large seasonal populations places an additional burden on municipal budgets.

Table 3.4.1.a Existing Community Facilities and Services Associated with Barrier Islands.

Jurisdiction	Municipal Sewer	Municipal Water	School Facilities	Fire Protection	Police Protection	Rescue Operations	Solid Waste Disposal	Recreation Facilities	Health Care
Brunswick County	-	X	X	-	X	-	X	X	X
Long Beach	- -	X	-	Volunteer Organization	X	Volunteer Organiation	X	X	-
Holden Beach	-	-	-	Cooperative arrangement	X	-	X	-	-
Caswell Beach	-	X	-	Volunteer Organization	-	Volunteer Organization	X	X	-
Sunset Beach	-	X	-	Volunteer Organization	-	Volunteer Organization	X	-	-
Ocean Isle	-	X	-	Volunteer Organization	-	Volunteer Organization	X	-	-
Carteret County	-	-	X	-	X	-	X	X	X
Emerald Isle	-	X	-	Volunteer Organization	X	Volunteer Organization	-	X	-
Pine Knoll Shores	-	X	-	Cooperative arrangement	X	-	X	X	-
Atlantic Beach	-	X	-	Volunteer Organization	X	Volunteer Organization	X	-	X
Currituck County		X	X	-	X	-	X	X	X
Dare County	-	-	X	Volunteer Organization	X	-	X	X	X
Nags Head	-	X	-	Volunteer Organization	X	-	X	-	-
Kill Devil Hills	-	X	-	Volunteer Organization	X	-	X	-	-
Southern Shores	-	X	-	Volunteer Organization	-	-	-	-	-
Hyde County	-	X	X	-	X	-	-	X	-

X Municipal service provided
- Municipal service not provided

Table 3.4.1.a Continued

Jurisdiction	Municipal Sewer	Municipal Water	School Facilities	Fire Protection	Police Protection	Rescue Operations	Solid Waste Disposal	Recreation Facilities	Health Care
New Hanover County			X						
Wrightsville Beach	X	X	-	Volunteer Organization	X	Volunteer Organization	X	X	-
Carolina Beach	X	X	-	Volunteer Organization	X	Volunteer Organization	X	X	-
Kure Beach	X	X	-	Volunteer Organization	X	Volunteer Organization	X	-	-
Onslow County	X	-	X	-	X	-	X	X	X
Pender County	-	-	X	-	X	-	X	-	X
Topsail Beach	-	X	-	Volunteer Organization	X	Volunteer Organization	X	-	-
Surf City	-	X	-	Volunteer Organization	X	Volunteer Organization	X	-	-

Source: Individual CAMA Plans.

Table 3.4.1.b. Community Services, Manpower, and Facilities for Selected Barrier Island Towns.

Jurisdiction	Police	Fire/Rescue Squad	Garbage Collection	Municipal Recreation
DARE COUNTY				
Nags Head	7 full time officers; 1 dispatcher; add 2 officers, for beach	39 certified volunteers; 3 pumpers	Off season pickup twice a week. Daily pick up in summer. Parttime help added during summer months.	None
Kill Devil Hills	9 full time officers; 5 auxiliary officers	36 volunteers; 3 pumpers part of County emergency medical system	Off season: residential pickup twice a week, commercial pick up 3 times a week. Summer: residential pickup 3 times a week, commercial pick up 7 times a week.	6.2 acres planned for tennis courts and ball fields.
CARTERET COUNTY				
Pine Knoll Shores	4 full time officers	Cooperative agreement with Atlantic Beach	Private contract, weekly collection.	8 small parks operated by property owners association. Pine Knoll Shores Golf and Country Club. Public beach. 27 acre, undeveloped tract owned by town.
Atlantic Beach	8 full time officers; 3 auxiliary officers; 3 radio operators; add 2 officers in summer	28 volunteer firemen; 3 pumpers. 22 man volunteer rescue squad.	Double garbage collection for summer.	None
PENDER COUNTY				
Topsail Beach	6 full time officers	27 volunteer firemen; 1 pumper. 20 man volunteer rescue squad	Private contract, collection twice a week during off season, 3 times a week during summer.	None
Surf City	4 full time officers; auxiliary staff	25 volunteer firemen, 2 pumpers; 1 tanker	Off-season pickup twice a week, summer pickup three times a week.	None
NEW HANOVER COUNTY				
Wrightsville Beach	18 full time officers; 6 auxiliary staff	24 volunteer firemen; 2 pumpers	Collection and disposal (incinerator). Residential collection twice a week.	13 acre municipal park
Carolina Beach	11 full time officers; 4 dispatchers; 1 secretary	4 full time firemen; 30 volunteers; 4 pumpers	Operates landfill. Off-season pickup twice a week. Summer pickup 4 to 7 times a week.	None

Table 3.4.1.b Continued

Jurisdiction	Police	Fire/Rescue Squad	Garbage Collection	Municipal Recreation
BRUNSWICK COUNTY				
Long Beach	10 officers; 3 auxiliary officers hired in summer	26 volunteer firemen; 2 pumpers; 1 tanker	Off season pickup twice a week. Additional pickups in summer.	10 acre park, 165 acre undeveloped tract.
Holden Beach	2 full time officers	Agreement with Tri-Beach Fire Service	Private contract. Off-season pickup once a week. Summer pickup twice a week.	None
Sunset Beach	4 full time officers who are trained in medical treatment	27 volunteer firemen	Off season pickup once a week. Summer pickup twice a week.	None

Sources: Telephone conversations with municipal employees 1980 and CAMA Plans.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.4 Community Services and Facilities

3.4.2 Public Water Supply

LOCAL SHALLOW GROUNDWATER IS PRIMARILY USED FOR INDIVIDUAL AND SMALL WATER SYSTEMS, WHILE PUBLIC WATER SYSTEMS USE DEEP INLAND GROUNDWATER RESOURCES

Shallow groundwater supplies are used for individual wells and small water systems. Most public supplies are drawn from confined or semi-confined layers of the upper sandy and limestone aquifer on the mainland. Use of the shallow water aquifer for water supply and discharges from septic tanks and package plants represents a possible resource use conflict.

Groundwater is essentially the only supply of freshwater on the barrier islands. Its availability for use as a water supply is dependent upon the thickness of the fresh water lens. In most places on the barrier islands, salt water or brackish water is found at such shallow depths that freshwater yields are less than 379 lpm (100 gpm) even when the aquifer is very permeable (Robinson and Mann 1977). The threat of salt water intrusion at higher pumping rates or longer durations further limits freshwater yield. Use of the unconfined aquifer for meeting large demands can be limited by:

- size (or depth) of the freshwater lens
- inadequate transmissivity
- greater demand occurs during periods of lesser recharge
- recharge affected by nearby development
- possibility of saltwater intrusion
- possibility of contamination from septic tank absorption fields or other surface activities

Some public water supplies are drawn from shallow wells. These include the Ocean Sands system in Currituck County and the Ocean Isle system in Brunswick County. In order to maintain adequate yields without saltwater intrusion, long horizontal collectors and low pumping rates are used.

The shallow water-table aquifer provides water supply to almost all individual wells and small water systems. Use of these shallow wells in areas near soil absorption sites for septic tanks or package treatment plants constitutes a possible conflict in resource use since using the aquifer for receiving wastewater potentially limits its value as a water supply. Since North Carolina does not allow deep injection of wastewaters, this conflict affects only the water table aquifer.

Higher yield public wells obtain water from the uppermost confined or semi-confined layers of the upper sandy aquifer. This is especially true inland on the peninsulas and on Roanoke Island, the site of the well field for the Dare County water system. The wells in this system obtain water from the uppermost confined aquifer known as the Yorktown Formation and are expected to supply water for Roanoke Island and the Dare beaches, north to Duck, North Carolina.

3.4.2 Continued

In many areas on the barrier islands, particularly the northeast Outer Banks areas located far from the mainland, the confined and semi-confined aquifers in the upper sandy aquifer are brackish and not suitable for water supply. The freshwater lens is so limited in some areas that desalinization is required. An example of this is the Ocracoke water system. Even in the Dare County water system well field on Roanoke Island, salt water intrusion is a concern because of the proximity of brackish water in the principal aquifer beneath the Dare beaches. For this reason, test wells are located in the sound between Roanoke Island and Bodie Island to monitor for possible saltwater encroachment (Jetters 1981).

On barrier islands south of Beaufort Inlet, adequate water supply is not generally a limitation to development. Most public water supplies obtain water from deep wells tapping the limestone aquifer. If adequate supplies are not available on these barrier islands, wells can be drilled on the mainland for supply water. For example, the Surf City water system obtains water from three mainland wells. Also, Ocean Isle beach, which presently uses a shallow well system, is now drilling deeper wells on the mainland.

Another source of water supply is available to barrier islands through county-wide systems. The Brunswick County water system already supplies the areas of Yaupon Beach, Long Beach, Caswell Beach, Holden Beach, and Oak Island. This water supply is obtained from deep inland wells.

Information on public groundwater supplies serving North Carolina barrier islands is provided in Table 3.4.2. Available water supplies are greater south of Beaufort Inlet; the groundwater supply to the northern barrier islands is limited. It is unknown at this time whether a lack of freshwater will be a factor which limits development in the Dare Beaches area. Adequate supplies are available for future development on the southern barrier islands.

As public water supply systems expand and the number of individual shallow wells in the water table aquifer is reduced, the possibility of contaminated water supplies from on-site wastewater disposal systems will likely decrease. However, in some areas of the barrier islands, individual wells will continue to be the primary source of water. Since the water table aquifer is vulnerable to surface pollution, development densities will need to be maintained at a level where risks of well contamination are minimized.

The use of deeper groundwater supplies with recharge areas on the mainland is not without limitations, however. These aquifers can be greatly affected by activities on the mainland. The effects may be more pronounced in the smaller confined aquifers of the upper sand aquifer than in the limestone aquifer, but increased runoff from inland construction reduces recharge to all the aquifers. The massive drainage systems used in large-scale agricultural activities could deplete quantities of groundwater available to barrier islands through the confined aquifers.

Table 3.4.2. North Carolina Barrier Islands Public Water Systems.

Water System	Service Area	Capacity m^3/d	Capacity mgd	Source
	Currituck Banks			
Ocean Sands	Ocean Sands Development	265.3	0.07	Water table aquifer
	Outer Banks: Dare County Beaches - Ocracoke			
Dare County Water System	Proposed: Roanoke Island and Dare Beaches north to Duck, N.C.	852.8	0.225	Confined aquifer (Yorktown Formation) Well field on Roanoke Island
Manteo	Manteo and vicinity			Deep wells in confined aquifer
Nags Head	Nags Head			Freshwater pond (water table aquifer)
Kill Devil Hills	Kill Devil Hills			Freshwater pond (water table aquifer)
Cape Hatteras Water Association	Avon, Buxton, Frisco and Hatteras			
	Bogue Banks			
Atlantic Beach	Atlantic Beach			Limestone aquifer; eight wells on island
Pine Knoll Shores	Pine Knoll Shores			
Bogue Banks Water Association	Emerald Isle, Indian Beach, Salter Path (western half of Bogue Banks)	238.8	0.63	Limestone aquifer; two wells on island
	Topsail Island			
Surf City	Surf City (also supplies water to Topsail Beach)	4169.0	1.1	Limestone aquifer; two wells located in mainland 1/2 - 1 mile west of AIWW
Topsail Beach	Topsail Beach			Surf City water system
West Onslow Beach	Topsail Island between Surf City and New River Inlet			Wells located on island
Onslow County	Proposed Topsail Island from New River Inlet south to Pender County line			Lower sandy aquifer; seven wells, 600 feet deep, located about 20 miles inland

Table 3.4.2. Continued.

Water System	Service Area	Capacity		Source
		m^3/d	mgd	
	Wrightsville Beach - Kure Beach			
Wrightsville Beach	Wrightsville Beach	6064.0	1.6	Limestone aquifer; eight wells located on the island
Coastal Plains Water Co.	Wilmington and Hanky Beach areas	4927.0	1.3	Limestone aquifer; seven wells on the island
Carolina Beach	Nearly all Carolina Beach	4927.0	1.3	Limestone aquifer; seven wells on the island
Kure Beach	Kure Beach	4775.4	1.26	Limestone aquifer; three wells, 200 feet deep.
	Brunswick County			
Ocean Isle Beach	Ocean Isle Beach	1137.0	0.3	Water table aquifer; 10 shallow wells with horizontal collectors; plans to construct three deep wells on mainland
Brunswick County Water System	Barrier communities of Yaupon Beach, Long Beach, Caswell Beach, Holden Beach and Oak Island as well as other areas of Brunswick County	17,055.0	4.5	Limestone aquifer; mainland wells
Sunset Beach	Sunset Beach			Limestone aquifer; five wells on mainland

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

AUTO ACCESS PROVIDED BY 17 BRIDGES, FIVE STATE-OPERATED FERRY ROUTES AND SEVERAL PRIVATE FERRIES

Auto access is provided to most barrier islands by way of bridges, causeways and ferries. Roads have been constructed along portions of most barrier islands, with the exception of the Cape Lookout National Seashore (Core Banks, Shackleford Banks and Portsmouth Island).

Automobile access to North Carolina barrier islands is readily available along most of the 596 km (308 mi) shoreline. The North Carolina Department of Transportation is responsible for the operation and maintenance of 17 bridges and causeways serving barrier islands. Several of these bridges are drawbridges, which permit large vessels to use the inlets and Intracoastal Waterway. No bridge can be built over navigable waters without the consent of the U.S. Coast Guard.

The State of North Carolina also operates five ferry routes that provide auto access to areas where bridges are not feasible. The three longest ferry routes are toll routes (Ocracoke to Swan Quarter, Ocracoke to Cedar Island, and Southport to Fort Fisher) while the other two routes are free. Schedules vary according to season. Several private ferries operate between Carteret County and the Cape Lookout National Seashore under National Park Service permits.

Roads have been constructed on most of the barrier islands and range from undeveloped scenic highways, such as on Hatteras Island, to highly developed arterials. The notable exception is the Cape Lookout National Seashore. The entire 88.6 km (55 mi) shoreline of this area (Core Banks, Shackleford Banks and Portsmouth Island) is without any developed roads. However, numerous private vehicles are used on this National Seashore, primarily by fishermen and off-road vehicle enthusiasts. In the future, the National Park Service may severely limit or prohibit vehicle use on the Cape Lookout National Seashore.

Appendix Table 3.4.3.a lists the bridges and causeways which provide access to the barrier islands. Appendix Table 3.4.3.b lists the ferry service and access points.

3.4.4 Public Beach Access

THE NATIONAL PARK SERVICE MAINTAINS THE MOST EXTENSIVE PUBLIC BEACH SYSTEM IN NORTH CAROLINA

The National Park Service maintains approximately 209 km (130 mi) of public beach frontage on the Cape Hatteras and Cape Lookout National Seashores. The state operates and maintains eight recreation or natural areas on the barrier islands with a total of 36.2 km (22.5 mi) of beach frontage. An inventory of local public access points indicates adequate access with limited support facilities.

The most extensive public beaches in North Carolina are maintained by the National Park Service. The Cape Hatteras National Seashore encompases approximately 121 km (75 mi) of beach frontage and includes several camping and parking areas with adequate access to the beach. The Cape Lookout National Seashore includes an additional 88.5 km (55 mi) of beach frontage, but at this time has limited ferry service and public facilities.

The State of North Carolina also operates and maintains several state parks and recreation, historic and natural areas on the barrier islands. Masonboro Island and Bald Head (Smith) Island are two undeveloped barrier islands partially owned by the state. Public access to these islands is not restricted; however, access is limited to private boats. Hammock Beach State Park on Bear Island is state-owned with access provided during summer months by state-operated ferries (passenger only). Fort Fisher Historical Area and Fort Macon State Park also include limited beach access. Total beach frontage in these five areas is approximately 36.2 km (22.5 mi). Three additional state operated areas, Carolina Beach State Park, Theodore Roosevelt Natural Area and Jockey's Ridge State Park, provide limited sound frontage on the barrier islands.

Public access to North Carolina beaches is addressed in the North Carolina Coastal Area Management Act. While CAMA establishes general policy guidelines, the major responsibility of insuring adequate access to public trust lands and waters rests with the local governments. According to state policy, public access shall include not only access rights but also adequate identification, parking and dune protection. Public access must be addressed in the local land use plans required by CAMA or in separate beach access plans. To date, six municipalities and two counties have prepared beach access plans in addition to the required land use plans. Generally, land use policies established at the local level simply encourage or support oceanfront beach access and make a general statement of support for increased future access. The plans seldom address specific implementation strategies.

An inventory of local public access points and related facilities was prepared by the N.C. Office of Coastal Management. This inventory indicates approximately 522 local public access points, 107 private and commercial access points and 34 boat access points. Approximately 14 public and private fishing piers are also located along the North Carolina coast. Most public

3.4.4 Continued

access points consist of streets with public rights-of-way extending to the ocean. Generally, parking areas and bathhouse/restroom facilities are not available at public access points. An estimate of oceanfront miles open to public use is not available.

Table 3.4.4 lists the available access points and related facilities along the barrier island beaches in North Carolina.

Table 3.4.4 Beach Access Points and Related Facilities in North Carolina.

Jurisdiction	Length of Oceanfront		Boat Access Areas	Beach Access Areas	Other Facilities
	km	mi			
Currituck Co.	32.2	20	21 boat access areas	Limited due to lack of developed roads	4 campgrounds (650 sites) 2 public swimming areas
Dare Co.	112.7	70	3 public boat ramps	Cape Hatteras National Seashore	Camping, parking and service facilities
Nags Head				31 ocean access points 2 sound access points (27 pedestrian only; 6 pedestrian and vehicular)	
Kill Devil Hills				30 streets with public rights-of-way to the beach	
Southern Shores			Private marina on the sound	34 private access points	
Carteret Co.	148.1	92		16 major access points 23 minor access points 7 restricted easements 12 private access points 31 commercial access points 30 streets with public rights-of-way to the beach	Fort Macon State Park
Club Colony Subdivision				4 private access points at the end of street rights-of-way. Public use and access is permitted.	Triple Pier Ocean Pier
Atlantic Beach				10 streets with public rights-of-way to the ocean	Boardwalk, parking, service facilities
Atlantic Beach to Bogue Inlet					Whaler Pier Iron Steamer Pier Emerald Isle Pier
Tip of Bogue Banks			Several privately-owned	pathways with public access permitted	
Emerald Isle				15-20 pedestrian walkways	2 public piers

Table 3.4.4 Continued

Jurisdiction	Length of Oceanfront		Boat Access Areas	Beach Access Areas	Other Facilities
	km	mi			
Pine Knoll Shores			1 boat ramp	3 parks on the ocean 2 parks on the sound	
Onslow Co.	64.4	40	-	19 pedestrian access points	Hammock's Beach State Park
Pender Co.	24.2	15	3 boat ramps 2 4-wheel drive vehicle access points	22 pedestrian walkways	Picnic area, camping
Surf City			33 access points (many with restricted access)		
Topsail Beach			2 private boat ramps (with public rental)	13 pedestrian walkways 4 unimproved public accessways	2 public piers
New Hanover Co.	43.5	27			Fort Fisher State Park
Carolina Beach			31 public access points	Service facilities	1 pier
Wrightsville Beach			4 boat ramps	69 public access points	Limited service facilities 2,430 parking spaces
Kure Beach				8 pedestrian walkways	1 pier, limited service facilities
Brunswick Co.			unimproved boat ramps		
Long Beach			4 boat ramps on the sound	60 streets with public rights-of-way to the beach 1 private access point (31 access points have developed walkways)	
Caswell Beach					Parking area with beach access
Holden Beach				25 private access points 33 public access points 4 semi-public access points 6 vehicle access points	
Yaupon Beach				11 streets with public rights-of-way to the beach	1 pier

Table 3.4.4 Continued

Jurisdiction	Length of Oceanfront		Boat Access Areas	Beach Access Areas	Other Facilities
	km	mi			
Ocean Isle Beach				13 major public access points	1 pier
Sunset Beach				33 streets with public rights-of-way to the beach (limited parking)	1 pier

Source: North Carolina Office of Coastal Management.

RETAIL SALES, TOURISM AND COMMERCIAL FISHING ARE KEYS TO THE BARRIER ISLAND ECONOMY

Retail sales, tourism and commercial fishing are major components of the barrier island economy; their relative importance varies from island to island. Only island-specific studies will provide a better understanding of the local economies.

In 1980, retail sales provided 69 percent of the dollars ($1.8 billion) generated by the economy of North Carolina's coastal counties. This was followed by tourism, contributing 12 percent ($308 million) and commercial fishing, contributing 7 percent ($175 million). Estimated construction and farm income contributed approximately 5 percent to the coastal economy. The least important contributor was planned industrial investments with 3 percent of the total dollars. Table 3.5 breaks these figures down to the county level.

Although statistics are not available, it is believed that tourism and commercial fishing play a large role in the economy of the barrier islands, diminishing the relative importance of retail sales. Retail sales are closely tied to trends in tourism. On an island by island basis, the relative contributions from these key economic indicators will vary and can only be determined by a site specific analysis for which surveys are conducted and records from local governments are assessed.

There is little likelihood that industrial activity will become an important part of the barrier islands' economy due to the lack of a large, skilled labor pool, adequate transportation routes and large tracts of land. Development restrictions caused by the fragile conditions of coastal areas also discourage industrial development. Most of the monies from farming originate on the mainland and contribute only in a small way to the island economy. However, both industry and farming probably provide employment to island residents who commute to the mainland in search of work.

Retail sales and the tourist industry are expected to grow and to continue to dominate the islands' economy. This forecast is based on projected increases in incomes and leisure time and a growing market area population. This overwhelming reliance on recreation as a primary source of income leaves the barrier islands' economies extremely vulnerable to national economic conditions and weather. The future of economically important activities that rely on natural resources such as commercial and sport fishing, and waterfowl hunting will depend on proper management, control of estuarine pollution and proper land use planning on the barrier islands to minimize habitat destruction.

Table 3.5 Estimated Dollars Spent by Key Sectors of the Economy in Counties Containing Barrier Islands, 1980 (Millions of Dollars).

	Dollars/Percent of Total for All Barrier Island Counties											
	Travel		Total Gross Retail Sales		Construction		Planned Industrial Investments		Estimated Farm Income		Total	
	$	%	$	%	$	%	$	%	$	%	$	%
North Carolina Total	2,400		36,887		2,144		2,240		3,621		47,292	
Total for All Barrier Island Counties	307.9	100	1,791	100	141	100	57.2	100	126.4	100	2,608.5	100
Brunswick County	19.0	6	132	7	5	4	1	2	25	20	182.0	8
Carteret County	68.7	22	215	12	34	24	7	10	12	10	336.7	14
Currituck County	2.3	1	46	3	6	4	None	0	13	10	67.3	3
Dare County	74.9	24	124	7	25	18	0.2	0	0.4	0	224.1	9
Hyde County	8.5	3	20	1	(-)	(-)	1	2	19	15	48.5	2
New Hanover County	98.7	32	829	46	52	37	53	79	3	2	1,035.7	43
Onslow County	30.0	10	365	3	18	13	5	7	24	19	442.0	18
Pender County	5.8	2	60	3	1	1	None	0	33	26	99.8	4
Percent Each Category Contributes to Economy of Barrier Island Counties		12		69		5		3		5		100

(-) Information not Available

Sources: Tourism: Rulison. 1980.
Retail Sales and Construction: N. C. Dept. of Commerce, Economic Development Div. July 1981.
Industry: Rakouskas. 1981.
Farm Income: Griffith. 1981.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.5 Economic Profile

3.5.1 Area Economic Indicators

INDICATORS CAN BE USED TO PREDICT THE ECONOMIC HEALTH OF THE BARRIER ISLANDS

While retail trade, manufacturing, and services provide most of the employment at the county level, it is believed that retail trade, services and commercial fishing provide most of the jobs on the barrier islands. Decreases in employment for various categories at the county level have been offset by increases in other categories, resulting in a net increase in employment for all counties. It appears that only Brunswick County and possibly Carteret County have per capita incomes that are keeping up with inflation.

The economic health of the barrier islands can best be determined through the assessment of various indicators. These economic indicators were only obtainable at a county level. They should, however, reflect the local barrier island economy as many island residents commute to and from the islands to work. Additionally, certain indicators such as tourism and commercial fishing and hunting directly influence the barrier island economy since these activities tend to be centered on many of the islands. However, the availability of island specific data is limited since many municipalities and even counties do not keep statistical data specific to the barrier islands.

Employment. Based on available information between 1973 and 1978, approximately 18,400 new jobs were created in the counties containing the barrier islands (Table 3.5.1.a,). In 1978, government employment provided the largest number of jobs followed by retail trade, manufacturing, and services. On the barrier islands it is believed that services, retail trade and commercial fishing (see Section 3.5.3) provide the greatest number of jobs.

With the exception of agriculture, there has been a tendency for all categories to provide increasing numbers of jobs between 1973 and 1978 (Table 3.5.1.b) for the entire coastal area. Agricultural employment appears to be declining in Brunswick, Carteret and New Hanover Counties. Other major declines in employment by county include:

Industrial Sector	Percent Decline by County
Manufacturing	-35 Hyde, -12 Pender
Transportation/Public Utilities	-12 Carteret, -4 Onslow, -5 New Hanover
Finance/Insurance/ Real Estate	-18 Carteret, -4 Onslow
Services	-3 Currituck, -40 Hyde, -10 Onslow

These decreases in employment on a county by county basis have been offset by increases in other categories resulting in a net increase in employment for all counties.

Table 3.5.1.a. Employment Trends by Major Industrial Category by Place of Work, 1973 and 1978.

Industrial Category	Brunswick County		Carteret County		Currituck County		Dare County		Hyde County		New Hanover County		Onslow County		Pender County		Total	
	1973	1978	1973	1978	1973	1978	1973	1978	1973	1978	1973	1978	1973	1978	1973	1978	1973	1978
Agriculture	256	248	197	187	265	279	-	-	289	294	130	125	712	725	772	710	2621	2568
Ag. Serv., Forest, Fisheries, Etc.	(D)	(D)	(D)	172	17	(D)	187	(L)	(D)	(D)	(D)	(D)	(D)	(D)	43	53	247	225
Mining	(D)	(L)	-	-	(D)	-	(D)	-	-	-	(D)	(D)	(D)	(D)	-	-	-	-
Construction	(D)	(D)	564	587	93	103	297	347	39	125	(D)	(D)	(D)	(D)	-	-	993	1162
Manufacturing	3022	3373	1754	2282	161	160	67	139	153	100	10603	9944	1851	2396	586	514	18197	18908
Transportation and Public Utilities	274	1154	489	429	37	32	(D)	(D)	19	(D)	3612	3417	887	931	94	117	5412	6080
Wholesale Trade	(D)	151	421	467	55	65	(D)	(D)	30	132	(D)	2264	332	383	173	241	1011	3703
Retail Trade	937	1152	1771	2468	143	218	916	1579	146	188	6629	7919	3976	4996	498	766	15,016	19,286
Finance, Insurance, & Real Estate	248	283	364	299	(D)	(D)	281	310	(D)	119	1569	1701	1021	984	50	75	3533	3771
Services	562	837	(D)	2368	241	234	844	1047	286	172	7045	8515	2806	2551	455	510	12,239	16,234
Government & Government Enterprises	1651	1844	1949	2429	507	768	911	1105	337	441	5952	6757	39,029	47,188	996	1368	51,332	61,900
Total Wages & Salaried Employment	7582	9680	11,699	13,827	2127	2542	4295	5689	1939	2174	41,258	43,043	51,884	61,570	3828	4488	12,461	143,013

(D) Not shown to avoid disclosure of confidential data, data are included in totals.

(L) Less than 10 wage and salary jobs.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System. 1973-1978.

Table 3.5.1.b Percent Increase/Decrease in Employment by Major Industrial Category by Place of Work, Between 1973-1978.

Industrial Category	Brunswick County	Carteret County	Currituck County	Dare County	Hyde County	New Hanover County	Onslow County	Pender County	Total
Agriculture	- 3	- 5	+ 5	(-)	+ 2	- 4	+ 2	- 8	- 2
Ag. Serv., Forest, Fisheries, Etc.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	+23	(-)
Construction	(-)	+ 4	+11	+17	+69	(-)	(-)	(-)	+17
Manufacturing	+12	+30	- 1	+108	-35	- 6	+29	-12	+ 4
Transportation and Public Utilities	+321	-12	-14	(-)	(-)	- 5	+ 5	+25	+12
Wholesale Trade	(-)	+10	+18	(-)	+340	(-)	+15	+39	+266
Retail Trade	+23	+60	+52	+72	+28	+20	+26	+53	+28
Finance, Insurance, and Real Estate	+14	-18	(-)	+10	(-)	+ 8	- 4	+50	+ 7
Services	+49	(-)	- 3	+24	-40	+21	-10	+12	+33
Government & Government Enterprises	+12	+25	+52	+21	+31	+14	+21	+37	+21
Total Wages & Saslaried Employment	+28	+18	+20	+33	+12	+ 4	+19	+17	+15

(-) Sufficient information not available to calculate.

Source: Percentages calculated from information in Table 3.5.1.a.

3.5.1 Continued

Per Capita Income Trends. All counties show an increase in annual per capita income between 1973 and 1979 (Table 3.5.1.c). However, assuming inflation has been approximately 9 percent per year, only Brunswick, New Hanover and Carteret Counties have per capita incomes that approach keeping up with inflation. Hyde, Pender Currituck and Onslow Counties appear to be depressed economically, having annual increases in per capita income of only 1.6, 2.6, 5.2 and 6.6 percent, respectively.

Tourism. Tourism is discussed separately in Section 3.5.2.

Retail Sales. Retail sales for various time periods between 1965 and 1980 are contained in Table 3.5.1.d. All counties have shown increases in retail sales between 1971 and 1980.

Construction Activity. Information on construction activity as indicated by dollars spent and number and type of structures built is contained in Table 3.5.1.e. A general increase in dollars spent and units built is shown between 1977 and 1979 and then a decline in 1980 is experienced for all categories in most counties, reflecting a nation-wide trend. Nevertheless, most counties have experienced an overall increase in real dollars spent on construction after accounting for an average inflation of 9 percent annually. Only Pender County shows a major decrease in both actual and real construction dollars.

Industrial Expansion. Recent new and expanded industrial investments (Table 3.5.1.f) are an indication of intended industrial activity. The monies indicated for a given year may actually be placed into the local economy over a period of years. During the 1970's Brunswick County has experienced the largest investment of industrial dollars in all of North Carolina. In 1980 and in the first six months of 1981, only New Hanover County shows any appreciable increase in dollars allocated for industrial development. Although most of the industrial expansion is on the mainland, it has contributed to the barrier islands economy by providing employment to island residents. Only a site specific survey will indicate how important this contribution has been. The planned commercial fish docks and processing facilities at Wanchese should greatly stimulate the island economy in this area.

Estimated Farm Economy. In fiscal year 1981, approximately $129 million was generaged by farming activities in the coastal counties within this EIS study area (Table 3.5.1.g). Farm income is largest in Pender County followed by Onslow, Brunswick and then Hyde Counties. Much of the activity is believed to take place on the mainland and contributes in only a small way to the barrier island economies.

Table 3.5.1.c. Annual Per Capita Income Trends.

	Per Capita Income (Dollars)			Average Annual[1]
	1973	1975	1979	% Increase Between 1973-1979
State of North Carolina	4263	4943	7382	8.2
Brunswick County	2911	4486	5598	9.8
Carteret County	3622	4323	6545	8.8
Currituck County	3877	3812	5279	4.5
Dare County	4156	4677	6559	6.7
Hyde County	3341	3384	3677	1.4
New Hanover County	4428	5051	7776	8.4
Onslow County	4070	4641	5981	5.7
Pender County	3213	3750	5224	7.2

[1] Computed using compound interest formula: Future Value = Present Value $(1 + \text{interest})^{\text{years}}$, where years equals 6.

Source: For 1973 and 1975: U. S. Department of Commerce, Bureau of Economic Analysis. Regional Economics Information System.
For 1979: North Carolina Office of State Budget and Management. 1981.

Table 3.5.1.d. Retail Sales and Farm Income for Counties in the EIS Study Area (in Millions of Dollars).

		Gross Retail Sales for Selected Business Groups			
Area	Total Gross Retail Sales	Food	General Merchandise	Automotive	Building Material
North Carolina					
1965-66	$ 8,549	$ 1,832	$ 1,551	$ 1,467	$ 869
1971-72	14,480	3,065	2,772	2,464	2,910
1978-79	30,866	6,878	5,532	5,530	2,910
1980-81	36,887	8,378	6,290	7,219	3,194
Brunswick County					
1965-66	21	5	4	5	2
1971-72	46	13	8	9	5
1978-79	99	30	21	15	9
1980-81	132	37	32	18	17
Carteret County					
1965-66	40	13	6	8	3
1971-72	76	23	12	12	8
1978-79	174	58	27	23	12
1980-81	215	78	34	27	12
Currituck County					
1965-66	7	1	2	1	0.1
1971-72	13	2	4	2	0.7
1978-79	97	36	9	8	9
1980-81	46	9	23	4	2
Dare County					
1965-66	15	5	2	2	0.6
1971-72	28	10	3	4	2
1978-79	97	36	9	8	9
1980-81	124	47	12	12	10
Hyde County					
1965-66	4	1	1	0.7	0.01
1971-72	6	1	1	1	0.01
1978-79	15	6	2	3	0.5
1980-81	20	7	7	4	0.5
New Hanover County					
1965-66	163	37	34	25	17
1971-72	312	60	73	53	37
1978-79	658	148	125	117	77
1980-81	829	186	148	165	83
Onslow County					
1965-66	88	21	14	18	4
1971-72	155	34	30	30	7
1978-79	325	84	56	58	17
1980-81	365	102	60	75	19

Table 3.5.1.d Continued

Area	Total Gross Retail Sales	Gross Retail Sales for Selected Business Groups: Food	General Merchandise	Automotive	Building Material
Pender County					
1965-66	14	3	3	4	0.3
1971-72	24	6	6	5	1
1978-79	49	11	13	10	4
1980-81	60	15	16	13	6

Source: N.C. Office of State Budget and Management Research and Planning Services. 1981. For 1965-1979: N. C. Department of Revenue, Sales and Use Tax Division. 1981.

Table 3.5.1.e Construction Activity in Counties Containing the Barrier Islands, North Carolina.

Area	Total Construction Activity (in Millions of Dollars)				Single Family, Units				Multi-Family, Units				Non-Residential, Units			
	1977	1978	1979	1980	1977	1978	1979	1980	1977	1978	1979	1980	1977	1978	1979	1980
North Carolina	1,638.7	1,980.4	2,228.5	2,143.7	33.3	35.9	36.3	31.5	6.4	9.5	11.0	9.1	9.3	9.9	11.1	10.2
Brunswick County	3.3	5.8	5.7	5.1	.1	.2	.2	.2	.002	.062	.002	.004	.043	.054	.054	.045
Carteret County	19.2	20.9	33.2	33.6	.711	.604	1.1	.9	.124	.119	.122	.060	.161	.147	.196	.164
Currituck County	4.1	7.2	9.3	5.9	.172	.336	.263	.222	0	.004	.002	0	.031	.149	.136	.122
Dare County	13.7	17.1	23.7	24.9	.390	.447	.580	.550	0	0	0	.117	.071	.073	.096	.040
Hyde County	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
New Hanover County	38.2	43.7	55.0	51.8	.941	1.07	.965	.833	.154	.015	.089	.014	.181	.221	.297	.330
Onslow County	6.3	9.7	12.6	18.3	.142	.158	.149	.166	0	.12	.652	0	.043	.077	.071	.105
Pender County	1.3	.933	.59	1.15	.031	.021	.014	.006	.004	0	0	.009	.001	.002	.001	.003

(-) Information not available

Source: N. C. Department of Commerce, Economic Development Divisions. July 1981.

Table 3.5.1.f Recent New and Expanded Industrial Investments in Counties Containing the Barrier Islands, North Carolina (in Thousands of Dollars).

Area	1970-79 New	1970-79 Expanded	1970-79 Total	1970-79 % of N.C. Total	1978&79 New	1978&79 Expanded	1978&79 Total	1978-&79 % of N.C. Total	1980 New	1980 Expanded	1980 Total	First 6 mos. 1981 New	First 6 mos. 1981 Expanded	First 6 mos. 1981 Total
North Carolina (Total)	5,615,672	5,571,754	11,187,426	100	2,831,413	1,618,735	4,450,148	100	1,252,809	987,287	2,240,196	549,493	573,384	1,122,87
Brunswick County	746,515	30,450	776,965	7.0	602,000	20,000	622,000	14.0	500	None	500	None	3,000	3,000
Carteret County	3,570	2,939	6,505	0.1	(-)	(-)	(-)	(-)	15	7,000	7,015	None	None	None
Currituck County	75	15	90	0.0	(-)	(-)	(-)	(-)	None	None	None	None	None	None
Dare County	(-)	1,215	996	0.0	781	-	781	0.0	None	180	180	750	None	750
Hyde County	400	150	550	0.0	(-)	(-)	(-)	(-)	1,340	None	1,340	None	None	None
New Hanover County	102,074	85,359	187,433	2.0	13,400	20,816	1,665	0.0	700	52,690	53,390	None	8,500	8,500
Onslow County	14,757	14,300	29,057	0.3	7,502	7,800	15,302	0.3	None	5,425	5,425	None	None	None
Pender County	490	390	880	0.0	(-)	(-)	(-)	(-)	None	None	None	None	None	None

(-) Information not available

Source: N. C. Department of Commerce, Economic Development Division. July 1980.

Rakouskas. 1981.

Table 3.5.1.g Estimated Farm Income From Counties Which Contain the Barrier Islands (in Millions of Dollars)

Area/Year	1965-66	1972-72	1978-79	1979-80	1980-81
North Carolina	1,389	1,542	3,240	3,406	3,621
Brunswick County	7	8	25	24	(25)
Carteret County	5	3	6	11	(12)
Currituck County	8	6	9	12	(13)
Dare County	0.03	0.07	0.3	0.4	(0.4)
Hyde County	5	5	12	18	(19)
New Hanover County	5	2	2	3	(3)
Onslow County	10	11	22	23	(24)
Pender County	18	16	25	31	(33)

( ) Estimated for fiscal year 1980 assuming a six percent increase based upon total increases in farm income for the state.

Source: For 1965-1978 data: N.C. Office of State Budget and Management Research and Planning Services. 1981.

For 1979-80 and 1981 data: J. Griffith. 1981.

TOURISM PLAYS AN IMPORTANT ROLE IN NORTH CAROLINA'S COASTAL COUNTIES

In 1980, approximately $310 million was spent in travel related activities in North Carolina's coastal counties. A large portion is believed related to barrier island tourism. Other indicators of barrier island tourism are ferry counts, highway traffic counts, state park and national seashore statistics, island-specific surveys and recreational activities related to natural resource use.

Indicators that can be useful in assessing trends in tourism on the barrier islands include travel surveys, ferry counts, highway counts, state park and national seashore statistics, island-specific surveys and recreational activities related to natural resource use. The latter will be discussed in Section 3.5.3; the former are discussed below.

Travel Surveys. Travel surveys have been conducted for the North Carolina Department of Commerce since the 1950's. They estimate total travel expenditures allocated at the county level based on hotel/motel receipts and expanded baseline historical data. These expenditures account for dollars spent during travel from tourism and private and commercial business. This information is not available below the county level; however, it is generally understood that a large percentage of the money spent in travel along the coastal counties is for barrier island tourism (Rulison 1980).

Table 3.5.2.a shows that in 1980, out of the 100 North Carolina counties, New Hanover ranked sixth, Dare, ninth and Carteret tenth in dollars expended for tourism. If inflation of 9 percent annually is assumed to occur, between 1973 and 1980, Dare, Onslow and Pender Counties experienced a net decrease in real dollars gained from increased tourism. The greatest increase in real dollars from tourism was in Brunswick and Carteret Counties. Table 3.5.2.b shows these changes.

Ferry Counts. An excellent indication of tourism trends can be obtained from ferry counts kept at the various operational headquarters. Most ferry users are assumed to be tourists. Ferry counts will provide indicators of traffic volume on the barrier islands from Cape Lookout and northward.

Highway Counts. Additional information on traffic volume as an indicator of tourism on the barrier islands should be obtainable from the North Carolina State Highway Commission. More information will be available on some islands than others, such as on the Dare County Beaches as monitored on Highways 64 and 158. Any site specific EIS should use the Highway Commission as a preliminary contact.

State Park and National Seashore Statistics. From Cape Lookout northward, and to a lesser degree on the barrier islands in the southern half of the study area, statistics are kept on visitors to state parks and the

Table 3.5.2.a Dollars Spent on Travel in Counties Containing the Barrier Islands of North Carolina (in Millions of Dollars).

Area/Year	1973	1974	1977	1980	Percent Increase between 1973-80
North Carolina	955	979	1,000	2,400	+151
Brunswick County	5.7	7.5	4,4	19.0	+230
Carteret County	18.6	34.8	9.7	68.7	+269
Currituck County	1.0	1.4	1.8	2.3	+130
Dare County	47.9	57.5	18.0	74.9	+ 56
Hyde County	3.0	2.1	1.1	8.5	+167
New Hanover County	47.4	44.0	33.3	98.7	+108
Onslow County	18.1	11.5	15.0	30.0	+ 66
Pender County	3.2	3.0	1.6	5.8	+ 81

Source: North Carolina Department of Commerce. Travel Surveys.

Note: 1973, 1974, 1979 and 1980 Travel Surveys conducted by Rulison.

1975, 1976, 1977, 1978 Travel Surveys conducted by Copeland and Copeland.

Travel includes travel for the purpose of tourism, and private/commercial business.

3.5.2 Continued

National Seashores. Annual figures are available by recreation activity in order to determine trends in visitation. Table 3.5.2.c indicates the visitation trends at the National Parks Service areas. Table 3.5.2.d indicates the major visitation activities, by month, at the Fort Macon State Park. These tables show the type of data that may be available for other State and National Parks.

Island-Specific Surveys. In many cases, especially in the southern half of the study area where many of the islands are commercially or privately owned, site specific information is not available. Some statistics may be available from the county or local governments. In other cases, individual establishments would need to be interviewed. The level of detail required to assess tourism will vary from island to island and will depend upon the relative importance of seasonal populations when determining present and future wastewater flows.

Table 3.5.2.b Increase/Decrease in Tourism Dollars from Inflation Versus Actual Increases in Travel in Counties Containing the Barrier Islands Between 1973-1980 (in Millions of Dollars).

	A	B	C	B - C	((B - C) ÷ A) X 100
Area	Travel Dollars 1977	Estimated 1980 Travel Dollars Assuming 9 Percent Inflation Compounded Annually Between 1973-1980	Actual 1980 Dollars Spent on Travel	Difference Between Actual and Estimated 1980 Travel Dollars (Real Travel Dollars)	Percent Increase (+)/ Decrease Between Real 1980 Travel Dollars and 1973 Travel Dollars
North Carolina	955.0	1,903.0	2,400.0	497.0	+ 54
Brunswick County	5.7	11.4	19.0	7.6	+133
Carteret County	18.6	37.1	68.7	31.6	+169
Currituck County	1.0	2.0	2.3	0.3	+ 30
Dare County	47.9	95.4	74.9	- 20.5	- 42
Hyde County	3.0	6.0	8.5	2.5	+ 83
New Hanover County	47.4	94.5	98.7	4.3	+ 9
Onslow County	18.1	36.1	30.0	- 6.1	- 33
Pender County	3.2	6.4	5.8	- 0.6	- 19

Source: Table 3.5.2.a

Table 3.5.2.c. Visitors to National Park Service Areas (in Millions).

Year	Fort Raleigh	Wright Bros Memorial	Cape Hatteras	Total
1973	.30	.41	1.71	2.42
1974	.33	.47	1.72	2.52
1975	.34	.48	1.79	2.62
1976	.33	.50	1.81	2.65
1977	.37	.53	2.03	2.94

Source: U. S. Dept of Interior, National Park Service. 1981.

Table 3.5.2.d. Fort Macon State Park 1980 Visitations by Major Activity.

Month	Total Attendance	Fishing	Picknickers	Swimmers	Hikers	Lectures Tours	Museum Attendance
Jan	19,700						
Feb	24,997						
Mar	39,058	451*	1,197*	50*	5,425*	864*	21,808
Apr	88,154	2,246*	5,950*	847*	8,925*	1,270*	41,430
May	121,931	5,670	13,980	6,045	12,765	6,905	55,942
June	140,061	5,975*	14,050*	20,885*	12,680*	4,370*	64,560
July	146,950	5,540	11,332	33,750	9,860	4,955	65,420
Aug	123,085	5,510*	9,675*	18,055*	8,655*	3,125*	56,140*
Sept	56,991	5,705*	3,365*	3,980*	5,205*	2,060*	29,180
Oct	56,060	7,655	2,190	92	4,670	285	34,600
Nov	43,594	7,820*	535*	0	2,490*	280*	27,510
Dec	18,945	1,310	190	0	1,495	0	11,158

* Estimates

Source: Carteret County Economic Development Council.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.5 Economic Profile

3.5.3 Natural Resources

NATURAL RESOURCES PLAY A MAJOR ROLE IN THE ECONOMY OF THE BARRIER ISLANDS

Duck and geese hunting, sport fishing and commercial fishing provide a major source of income to residents of the barrier islands and to North Carolina. During the 1978-79 season an estimated 108,000 hunter days generated $1.5 million in income to professional guides and an additional $3-4 million in general revenue. It is estimated that 1.5-2.0 million angler days are spent sport fishing in the estuarine waters of North Carolina. Additionally, professional tournament fishing and charter boat fishing bring in millions of dollars in revenue to the barrier island economy each year. The intracoastal commercial fishing of North Carolina was worth an estimated $42 - $50 million to the total economy in 1979.

The natural resources of the North Carolina barrier islands play a major role in the economy of the area by attracting tourists for recreational purposes. Major economic benefits are gained from waterfowl hunting, sport fishing and commercial fishing.

Waterfowl Hunting. During the 1978-79 waterfowl season in North Carolina, 30,000 federal duck stamps were sold. During the same period, a total of 215,000 duck-hunter days were tabulated in North Carolina. It is estimated that about 72,000-108,000 of these days were spent on or around the barrier islands (Florshutz 1981). Additionally, approximately 200 professional hunting guide licenses were issued during that season. It is believed that most guided hunts take place in and around the barrier islands, especially in Currituck Sound where approximately one third of the duck population of North Carolina over-winters (Lewark 1981).

Approximately $1.5 million in income is associated with the provision of guide services (Lewark 1981). In addition, it is estimated that between $3 and $4 million (in addition to revenues from professional guide services) were expended for waterfowl hunting. The actual percentage of these dollars contributed to the economy of the barrier islands is unknown. Appendix 3.5.3.a contains information on management techniques and geographical distributions of waterfowl that play a major role in the waterfowl economics.

Sport Fishing. The importance of sport fishing as an economic resource cannot be overemphasized. In 1980 approximately 300,000 boats were registered in North Carolina, of which 250,000 are believed to have spent some time in saltwater. It is estimated that approximately 1.5-2.0 million angler days per year are spent in estuarine waters east of a north/south line running three miles inside Albemarle and Pamlico Sounds. (This does not include inshore fishing of mainland waters and rivers). A detailed description of the geographical distribution of sportfishing is contained in Appendix 3.5.3.b.

3.5.3 Continued

In addition to the dollars spent on lodging, food, gas and gear for recreational fishing, professional tournament fishing and charter boat fishing bring significant revenues to the barrier island economies. Although research is still preliminary, a typical bill fishery tournament with 100 entries can provide about $430,000 to a barrier island community. A typical King Mackeral tournament with 100 entries can bring in about $81,600 to a barrier island community. A surf fishing tournament with 100 entries can bring in as much as $100,000 to a community. Details of the economically important sport fishing on the barrier islands is contained in Appendix 3.5.3.c.

Commercial Fishing. Six major commercial intracoastal fisheries are located along the barrier islands: oyster, bay scallop, clam, blue crab, shrimp and fin fish. The total economic value of these fisheries in 1979 was approximately:

-Oyster Fishery, $2.3-2.8 million
-Bay Scallops Fishery, $1.3-1.5 million
-Clam Fishery 11.0 - $13.0 million
-Blue Crab, $12.0-14.0 million
-Shrimp Fishery, $16.0-19.0 million
-Southern Flounder Fishery, $2.5-3.5 million
-Sciaenid Fishery, $10.0-12.0 million

According to the North Carolina Division of Marine Fisheries, the total value of these intracoastal fisheries in 1979 was $42.6 to $50.3 million. The total value to the economy of all fish landed in North Carolina was between $146 and $175 million. Detailed information on these commercial fisheries discussing environmental limitations, geographical distribution and fishing techniques of North Carolina's intracoastal fisheries is included in Appendix 3.5.3.d. Information about intracoastal commercial fish landings from 1970-1979 by water body is contained in Appendix Table 3.5.3.a and by fishery in Appendix Table 3.5.3.b.

REGULATIONS MANAGE USE OF NATURAL RESOURCES, DEFINE LAND USE RELATIONSHIPS, AND PROTECT HEALTH OF COASTAL RESIDENTS

Federal state and local laws work together to provide a comprehensive approach to controlling development and preventing adverse impacts to the natural and man-made environments. The role played by each level of government is examined.

The purpose of development controls is to regulate the uses man proposes to make of land and water resources. Statutes are based upon the police powers of the legislative branch of government to protect the health, welfare and safety of the public. The regulation of drinking water supplies and wastewater management systems responds to the need to protect the public from environmentally transmitted pollution and disease problems. Other regulations prohibiting development in ocean hazard areas promote public safety and minimize property losses. The exclusion of development from environmentally sensitive areas helps to protect natural resources, many of which are of commercial importance to barrier island economies.

A wide variety of federal, state and local laws control development on the barrier islands. At least 12 federal agencies play a role in protecting the islands' resources and directing development away from sensitive areas. A number of federal laws are supplemented by state laws. Many of these laws set standards which are enforced by local governments. In other instances, the state remains the implementing agent.

Some development controls state where development may not take place; others premit development under controlled conditions; and others, such as zoning ordinances, state where certain types of development must take place. The following sections examine the roles federal, state and local governments play in land use regulations and wastewater facilities controls.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.6 Development Controls

3.6.1 Land Use Regulations

LAND USE AND ENVIRONMENTAL REGULATIONS ENCOURAGE
WISE USE OF ALL AVAILABLE RESOURCES

Through a hierarchy of federal, state, and local regulatory mechanisms, coastal developers must consider the impact of proposed construction activities on various economic, social and environmental resources.

A variety of statutory law has evolved through the country's history to address the full spectrum of human activities involved in utilizing land and water resources in a reasonable manner. These laws and their attendant implementing regulations cover all aspects of life ranging from what land uses a man may impose on his neighbor to preventing the pollution of a community resource such as a water supply.

Laws are enacted in response to a perceived public need and each particular law is usually applicable to an issue that corresponds to the jurisdiction of the complaint. Thus, the effects of water pollution are addressed and regulated by the federal government since rivers flow beyond local and state boundaries, while zoning controls of neighboring land uses are instituted at the local level where the specific grievances can be resolved by the conflicting parties.

The following listing of federal, state, and local laws was excerpted from the publication Ecological Determinants of Coastal Area Management, Volume I and II, authored by David Brower, Dirk Frombrenberg, Francis Parker, B. J. Copeland and Raymond Allen under the Univ. of North Carolina Sea Grant Program, 1976. These descriptions are presented to give a general understanding of the environmentally related regulations that affect barrier island resource use.

3.6.1.1 Federal

FEDERAL REGULATION FOCUSES ON GENERAL PROBLEMS COMMON TO LOCATIONS THROUGHOUT THE NATION

Nationwide laws address universal issues such as transportation and environmental degradation which affect the well-being of all citizens. Common resources outside the control of individual states, such as the ocean's resources within the nation's 200 mile jurisdiction, are also within the purview of federal management. Twelve federal agencies administer programs which affect the barrier islands' natural resources.

Federal laws and programs have, in many ways, encouraged and allowed development of barrier islands, resulting in potential problems of public health and safety, increasing costs and loss of important public benefits provided by unspoiled barrier islands (U.S. Dept. of Interior 1979). This situation is not the result of any directed federal policy to encourage barrier island development. Rather, it results from a general lack of knowledge and understanding of barrier islands as unique resources warranting special attention. While a broad range of federal and state authorities address aspects of barrier island land management, barrier islands as a whole are treated only as a peripheral concern. As a consequence, the land management needs of barrier islands are not effectively being met (U.S. Dept. of Interior 1979).

A broad range of federal programs apply to barrier islands. These programs address various aspects of barrier island protection and development and influence the degree and extent of development of these islands. The following is an identification of twelve federal agencies which have programs affecting barrier islands and the laws and regulations under which they operate.

Council on Environmental Quality (CEQ)

The Council was established by the National Environmental Policy Act of 1969 (NEPA) (83 Stat. 852; 42 U.S.C. 4321 et. seq.) to formulate and recommend national policies for improving the quality of the environment. The Office of Environmental Quality, which provides staff to the Council, was subsequently established by Title II of the Environmental Quality Improvement Act of 1970 (84 Stat. 114; 42 U.S.C. 4372).

Environmental Protection Agency (USEPA)

In addition to its responsibilities for monitoring environmental impact statements, USEPA programs which may affect barrier island development primarily are the result of three major legislative acts:

3.6.1.1 Continued

1. The Clean Water Act (Clean Water Act of 1977 and the Federal Water Pollution Control Act Amendments of 1972; P.L. 92-500; 33 U.S.C. 1281 et. seq.) which authorizes:

   a. Wastewater Treatment Construction Grants: Supports the planning and construction of wastewater treatment facilities. (Sec. 201)

   b. Water Quality Management Planning: Grants to state and designated areawide planning agencies for the development and implementation of areawide water quality management programs. (Sec. 208)

   c. National Pollution Discharge Elimination System (NPDES): NPDES permits are issued to individual point source dischargers (including municipal waste treatment plants) setting limitations on amount of pollutants a discharge may contain. (Sec. 402)

   d. Permits for Dredged or Fill Material (Sec. 404).

2. Clean Air Act of 1963, P.L. 88-206, 42 U.S.C. 1857; as amended by P.L. 91-604, the Clean Air Act Amendments of 1970.

   a. State Implementation Plans (SIP): Submitted by each state for USEPA approval, SIP's set emission levels and control strategies necessary to achieve and maintain national ambient air pollution standards set by USEPA.

   b. Air Quality Maintenance Areas (AQMA): Usually an urbanized area or SMSA identified in SIP's or designated by the USEPA Administrator which, because of current air quality and/or projected growth, has the potential for violating any national air quality standard within ten years. Addition of major new sources or modification of existing emission sources is controlled to prevent further air quality deterioration.

   c. Air Pollution Program Grants: Federal funds are available for 1) up to two-thirds of the cost of planning, developing, establishing or improving state air pollution prevention and control programs and 2) up to one half of the cost of maintaining such programs.

   d. Section 309 Review: This section of the Clean Air Act requires the USEPA Administrator to "review and comment ...on the environmental impact of any matter relating to... the authority of the Administrator contained in (1) any legislation proposed by any federal department or agency; (2) newly authorized federal projects for construction and any major federal agency action other than a project for construction to which Section 102(2)(c) of (NEPA) applies, and (3) proposed regulations published by any department or agency...." The Administrator's comments must be made public and if he determines that the matter under review "is unsatisfactory from the standpoint of public health or welfare or environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality."

3.6.1.1 Continued

This requirement brings within USEPA purview any major federal action proposal that impacts health, welfare or the environment on the barrier islands. This includes actions in the territorial sea, the contiguous zone or the oceans that would impact these islands.

USEPA policy and regulations require that activities, such as those listed above, conform with related statutory requirements.

The Coastal Zone Management Act (CZMA) which could provide special considerations for the barrier islands requires that:

- The requirements of the Federal Water Pollution Control Act and the Clean Air Act be incorporated into CZM programs developed by the States, and
- All federal activities in the coastal zone (including issuance of permits and licenses) be consistent with State CZM programs.

3. National Environmental Policy Act of 1969 (NEPA) P.L. 91-190, 42 U.S.C. 4321-4347

The National Environmental Policy Act of 1969 recognizes the value that natural ecological systems provide and mandates that all federal agencies incorporate the consideration of environmental values into their administrative procedures. The Act mandates that an environmental impact statement (EIS) be filed on all "major Federal actions significantly affecting the quality of the human environment." In practice, the courts have held that federal licensing, permits, loan programs and construction activities as well as other actions are covered by NEPA. EISs must include a detailed discussion on 1) the environmental impact of the proposed action, 2) any adverse environmental effects that cannot be avoided should the proposal be implemented, 3) alternatives to the proposed action, 4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and 5) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented (P.L. 91-190, Sec. 102(c)).

EISs are reviewed by federal, state and local agencies, and by the public. Specific review varies according to special expertise needed and the environmental impact involved. The USEPA has the authority to review and comment on EISs with respect to air or water quality, noise abatement and control, pesticide regulation, solid waste disposal and radiation. Although the Council on Environmental Quality has the approval power, USEPA is relied upon for impact analysis in the above areas.

Many EISs involving the North Carolina coast have already been undertaken. Such activities as the U.S. Army Corps of Engineers' beach and inlet stabilization and protection program as well as the dredge and fill permit program have a great effect on both the barrier island and estuary systems. The Department of Transportation highway program and the Farmers Home Administration funding program for community facilities are examples of other major federal actions that can have a significant direct effect on coastal ecological processes.

National Park Service (NPS)

The NPS authorities for barrier island activities stem mainly from the Act of August 25, 1916; P.L. 64-235; 16 U.S.C. Section 1 et. seq. This act extablished the basis for the current system of national parks, monuments, and recreation areas and for the service which administers them. NPS activities on barrier islands also may be affected by the:

a. Park, Parkway, and Recreation Study Act of June 23, 1936; P.L. 74-770; 16 U.S.C. 17;

b. NPS Administrative Authorities Act; P.L. 94-458; 16 U.S.C. 1a-1; and

c. The Wilderness Act; 16 U.S.C. 1131-1136.

The national seashores and recreation areas which are situated on barrier islands were created individually through separate acts of Congress. Each act specifies the purposes for which the unit was established, identifies the general boundaries, sets out basic management guidelines and establishes the authorities governing the Secretary's right to acquire land by various means. These authorities vary widely and extend from the exercise of powers of eminent domain to acquisition by donation or purchase from willing sellers.

For the purposes of "developing coordinated and adequate public park, parkway and recreational-area facilities for the people of the United States," the Park, Parkway, and Recreation Area Study Act of June 23, 1936; P.L. 74-770; 16 U.S.C. 17 authorizes the Secretary of the Interior, operating through the NPS "to aid the several States and political subdivisions thereof in planning such areas therein, and in cooperating with one another to accomplish these ends." Assistance provided under the Act may include technical and advisory services on organization, operation and maintenance, historical and archeological programs and general development planning.

The historical and archeological functions of the NPS are authorized by:

a. The Historic Sites Act of August 21, 1936; 16 U.S.C. 463

b. The National Historic Preservation Act of 1966; 16 U.S.C. 470

c. The Archeological and Historic Preservation Act; amendments of 1974; 16 U.S.C. 469

Fish and Wildlife Service (FWS)

The FWS draws its authorities for barrier island related activities from a number of Acts of Congress. These include, in addition to the Fish and Wildlife Act of 1956, as amended, the following:

3.6.1.1 Continued

a. Fish and Wildlife Coordination Act; 16 U.S.C. 661-667e

b. National Wildlife Refuge System Act; 16 U.S.C. 668dd-668jj

c. Migratory Bird Conservation Act; 16 U.S.C. 702-718h

d. Endangered Species Act of 1973; 16 U.S.C. 1531-1543

e. Wildnerness Act; 16 U.S.C. 1131-1136

f. Recreation Act of 1962; 16 U.S.C. 460k-460k-4

g. Various acts establishing specific wildlife refuges with the system.

Bureau of Land Management (BLM)

The Federal Land Policy and Management Act of 1976; P.L. 94-579; 90 Stat. 2743 is referred to as the BLM Organic Act and it is from this Act, plus its responsibilities under the Outer Continental Shelf Lands Act, that BLM derives its authorities for program which affect barrier islands.

Section 211 of the Organic Act authorizes the Secretary of Interior to convey, under the provisions of the Recreation and Public Purposes Act, 43 U.S.C. 869 et. seq., to states and their political subdivisions any unsurveyed islands determined to be public lands of the United States.

Office of Coastal Zone Management (NOAA - Department of Commerce)

The Coastal Zone Management Act of 1972, 16 U.S.C. 1451, (as amended in 1976) encourages:

> the participation of the public, of federal, state and local governments and of regional agencies in the development of coastal zone management programs to achieve wise use of land and water resources of the coastal zone.

The act provides for a voluntary program; no sanctions are imposed upon any state or territory which chooses not to participate.

U. S. Army Corps of Engineers

The U.S. Army Corps of Engineers (ACOE) administers various programs which have potential for affecting barrier islands. These programs and the authorities for implementing them include:

a. Beach Erosion Control	Section 103 of P.L. 87-874, Rivers and Harbors Act of 1962, as amended
b. Flood Control and Coastal Erosion Control	Public Law 84-99, 33 U.S.C. 701n, Flood control Act of 1941; 77-228, 33 U.S.C. 701b et. seq. as amended by P.L. 87-874

3.6.1.1 Continued

c. Flood Fighting and Coastal Protection Works (federally authorized)	Flood Control Act of 1941; P.L. 77-228 as amended by P.L. 84-874
d. Floodplain Management	Section 206 of P.L. 86-645 Flood Control Act of 1960 as amended
e. Navigation	Section 107 of P.L. 86-645, Rivers and Harbor Act of 1960 as amended
f. Regulatory Functions	Sections 9 and 10, Rivers and Harbors Act of 1899; Clean Water Act of 1977

A permit must be obtained from the ACOE for any structure in or over navigable water. Also required is a permit to dredge and/or fill, to discharge dredged materials, to alter the course or location of a port, harbor, canal or enclosure within a channel of navigable water.

Authority to regulate structures other than bridges in or over navigable waters and to regulate alterations of navigable water channels is found in the commerce clause of the U.S. Constitution. Authority for dredge and fill regulation is granted in Section 10 of the Rivers and Harbors Act. Authority for regulation of dredged material discharge is granted based on water quality aspects of dredged materials.

North Carolina has a similar dredge and fill permit program which applies to coastal waters and coastal wetlands. Coordination between federal and state dredge and fill permits exists in the form of a state-issued permit.

Federal Emergency Management Agency (FEMA)

The Federal Disaster Assistance Administration (FDAA) was abolished by Executive Order 12148 effective July 15, 1979, and FEMA has now assumed the FDAA responsibilities. The Federal Insurance Administration (FIA) was transferred to FEMA by Executive Order 12127 on April 1, 1979. However, FIA retains its identify as an agency within FEMA.

FEMA draws its basic authorities from the Disaster Relief Act of 1974, P.L. 93-288, 42 U.S.C. 5121. The program objectives are to provide assistance to states, local government, individuals and owners of selected non-profit facilities "in expediting the rendering of aid, assistance, and emergency services, and the reconstruction and rehabilitation of devastated areas..." and "to alleviate the suffering and damage which result from such disasters...."

Section 201 of the Act authorizes the establishment of disaster preparedness plans, utilizing all appropriate agencies. It provides for technical assistance and grants to the states in developing comprehensive disaster plans and programs to include hazard reduction, avoidance and mitigation.

Section 406 also has relevance to barrier island situations. This section requires, as a condition for any loan or grant made under the provisions of the Act, that the state or local government agree that the natural hazards of the area in which the loan or grant is to be used will be evaluated and appropriate action taken to mitigate those hazards.

The Federal Insurance Administration draws its authorities primarily from the National Flood Insurance Act of 1968, P.L. 90-448, 42 U.S.C. 1441, as amended by the Housing and Urban Development Act of 1968, P.L. 91-152, and the Housing and Community Development Act of 1974, P.L. 93-383, 42 U.S.C. 5301; and the Flood Disaster Protection Act of 1973, P.L. 93-234, 42 U.S.C. 4001, as amended by the Housing Authorization Act of 1976, P.L. 94-375, 12 U.S.C. 1701.

Communities must apply in order to qualify for the National Flood Insurance Program. When a community qualifies for flood insurance under the Emergency Program, then it receives insurance at subsidized rates. After a Flood Insurance Rate Map is completed, which defines the boundary lines of a flood having a 1 percent chance of occurring in any year (a 100-year frequency flood, and after additional land use controls are adopted, the community qualifies for the Regular Program, which provides more comprehensive insurance at either a subsidized or actuarial rate.

Under the provisions of the Flood Disaster Protection Act of 1973, communities having one or more identified special flood hazard areas must enter into the National Flood Insurance Program or be denied federal or federally-related financial assistance for acquisition or construction purposes within those areas.

Floodplain Management, Executive Order 11988

Executive Order 11988, Floodplain Management, signed May 24, 1977, revoked and replaced Executive Order 11296 issued on August 10, 1966. It established new federal policy for executive agencies and requires agencies to issue new or amended procedures to ensure the non-hazardous use of riverine, coastal and other floodplains. The Order directs federal agencies to avoid, to the extent possible, the long and short term adverse impacts associated with activities in floodplains and to avoid the direct or indirect support of floodplain development.

Protection of Wetlands, Executive Order 11990

Executive Order 11990, issued on May 24, 1977, directs federal agencies to provide leadership in minimizing the destruction, loss or degradation of wetlands. All agencies are ordered to avoid "to the extent possible: the destruction or modification of wetlands whenever there is a practicable alternative." Like Executive Order 11988 relating to floodplains, the Order is both procedural and substantive and applies to agencies involved in 1) acquiring, managing and disposing of federal lands and facilities, 2) providing federally undertaken, financed, or assisted construction and improvements, and 3) conducting federal activities affecting land use, including but not limited to water and related land resources planning, regulatory and licensing activities.

3.6.1.1 Continued

Department of Housing and Urban Development (HUD)

The Housing and Community Development Act of 1974 (P.L. 93-383), 42 U.S.C. 5301, merged several categorical grant programs into the Community Block Grant Program (CDBG) and authorized funds for a three year period. Title I of the Housing and Community Development Act of 1977 (P.L. 95-128) amended the earlier Act and extended funding authorizations for CDBG for an additional three years. CDBG has become HUD's primary vehicle for providing community development assistance.

Several mortgage and loan insurance programs are administered by the Federal Housing Administration (FHA) within HUD. These programs include insured mortgages or loans for, among others, multi-family dwellings, condominiums, single family homes, hospitals and replacement of dwellings extensively damaged by major disasters.

Another program in HUD which has an important indirect impact on barrier island development is the Interstate Land Sales Full Disclosure Act program established by Title XIV of P.L. 90-448, 15 U.S.C. 1701.

Farmers Home Administration (FmHA)--Department of Agriculture

The FmHA derives its authorities for programs which may impact on barrier islands from a number of Acts of Congress. Among the more important of these are:

1. The Consolidated Farm and Rural Development Act, P.L. 92-419, 7 U.S.C. 1921 as amended by P.L. 93-237, 15 U.S.C. 633. Sections of this Act authorize:

    a. Emergency loas to cover losses resulting from designated disasters and to permit continued operations with credit from other sources

    b. Loans and grants for installing, repairing, improving or expanding rural water and waste disposal systems; collection and distribution lines, pumping facilities and treatment plants all are eligible items

    c. Loans for financial assistance for improving the economic and environmental conditions of rural areas by developing business, industry, and employment

    d. Loans for the development of community services such as fire and rescue services, transportation, industrial and business development, community social, cultural, health and recreation benefits.

2. Housing Act of 1949, as amended
This Act provide authorities for direct or guaranteed/insured loans for purchase and development of land in rural areas for subdivision purposes. Included are water and sewer facilities.

3.6.1.1 Continued

3. Food and Agriculture Act of 1962
   This Act authorize loans to local sponsoring agencies in authorrized areas for:

   a. Rural community public outdoor oriented water based recreational facilities
   b. Soil and water development, conservation, control and use facilities
   c. Community water storage facilities in authorized Resource Conservation Development Areas

Small Business Administration (SBA)

The SBA draws its authority for administration of programs which may impact barrier islands from the Small Business Act of 1953, P.L. 83-163, 15 U.S.C. 631, as amended. Amendments to the Act have been numerous, but two which may be particularly relevant to barrier island protection were included in the Disaster Relief Act of 1970 and the Federal Water Pollution Control Act Amendments of 1972.

Department of Transportation (DOT)

The Department of Transportation includes several agencies whose program authorities have great potential for impacting barrier islands. Two, the U.S. Coast Guard (U.S.C.G.) and the Federal Highway Administration (FHWAS), are particularly important. A third, the Federal Aviation Administration (FAA), has a lesser impact on the islands.

Authority for approving permits to construct bridges over navigable water, including those necessary to connect barrier islands to the mainland (or to each other), was transferred from the Corps of Engineers to the U.S. Coast Guard by the DOT Act of 1966, 49 U.S.C. 1655(g)(6).

The FHWA administers the federal-aid highway program of financial assistance to states for highway construction. Revenues derived from special taxes on highway users provide the federal share of the financing for federal-aid primary, secondary, and urban roads and streets.

STATE SETS STANDARDS FOR IMPLEMENTATION AT THE LOCAL LEVEL

Since most natural resources extend beyond the jurisdiction of local governments, the state has developed regulations that set minimum standards for utilization of resources. Examples of these resources include water supplies, land and land cover, and renewable food resources such as shellfish.

The State of North Carolina is authorized to regulate the following activities and program areas:

Public Drinking Water Supplies

Authority for regulation of water and sewer sanitation has been granted to the Department of Human Resources, Commission for Health Services by N.C.G.S. 130-157. Under the Safe Drinking Water Act of 1974, USEPA is authorized to establish national standards for drinking water for protection of public health. The states enforce these standards and supervise water supply systems and sources. In addition, states may set secondary standards for taste, odor and appearance of drinking water. This tool provides for the regulation and inspection of all public drinking water supplies including watersheds where drinking water is obtained and for the prevention of contamination of these supplies by sewage and industrial waste.

Prohibited Discharges to Water

A permit must be obtained from the Environmental Management Commission to discharge either directly or indirectly or cause to mix with the waters of the state any waste which violates the effluent standards established for the point source. Waters of the state are defined in N.C.G.S. 143-213 (2) to include all bodies or accumulations of water, surface or underground, public or private, and natural or artificial which flow within or through the state. Thus the water quality of the state is regulated by the non-point source approach of water quality standards for each stream classification and by the point source approach of effluent standards for each type of point source discharge.

Authority is given in N.C.G.S. 143-215 to the Environmental Management Commission. The Department of Natural Resources and Community Development shall, under the rules and regulations adopted by the Environmental Management Commission, approve any public or community sewage system and any system which discharges to the land surface or surface waters (N.C.G.S. 130-166.65).

The effluent standards and stream classification standards are set by USEPA in accordance with 33 U.S.C. 402. However, the regulatory power is now granted to the state since it meets the requirements of the National Pollutant Discharge Elimination System permit program.

3.6.1.2 Continued

Ocean Disposal

Discharges of waste including thermal discharges into the Atlantic Ocean are prohibited by statute. However, the Environmental Management Commission has the power to adopt regulations to permit exceptions. The Environmental Management Commission is given this regulatory authority in N.C.G.S. 143-214.2. On the federal level, USEPA has the regulatory authority for discharge from point sources under Section 402 (National Pollutant Discharge Elimination System) of the Federal Water Pollution Control Act. This includes point sources such as ocean outfalls. Under the Marine Protection, Research and Sanctuaries Act of 1972 (P.L. 92-532), USEPA has the authority to issue permits for ocean dumping of all waste based on criteria established by USEPA, the U.S. Army Corps of Engineers and the Office of Coastal Zone Management jointly.

Local governments do not have direct jurisdiction over ocean waters and therefore must appeal to the state and/or federal agencies to regulate private activities of those waters. Any locality that plans to use ocean dumping or wants to see that ocean dumping by private persons or nearby jurisdictions is properly analyzed and regulated may need to invoke the state and federal ocean dumping permit process.

Construction of Water Wells

This type of regulation may be used to control the construction of water wells with a withdrawal capacity of 379,000 lpd (100,000 gpd) or greater, great enough to significantly affect groundwater, or wells of any size in an area where groundwater resources require special protection. Permits may be denied upon a finding that a well is or may be a source or channel of contamination of groundwater supplies or aquifers. Regulation may be extended to periodic inspection and/or monitoring of water resources to assure that the wells function without damage to water resources from salt water intrusion and/or improper waste disposal.

Statutory authority exists in North Carolina purusant to N.C.G.S. 87-88. The Division of Environmental Management in the Department of Natural Resources and Community Development is responsible for administering this regulation.

Septic Tanks

Regulation of septic tanks can ensure that these facilities are not permitted in areas where soil type, subsurface conditions, groundwater conditions or proximity of surface water dictate a high likelihood of malfunction, sanitation problems or environmental pollution. Authority to regulate septic tanks exists in North Carolina pursuant to N.C.G.S. 130-166.65.

Owners of single or multi-family residences, places of business, and places of public assembly are required to provide sanitary sewage treatment and disposal systems consisting of approved privies, septic tank systems, incinerators, mechanical toilets, composting toilets, recycling toilets, or other such systems. The effluent from such systems which is not discharged to the land surface or surface waters shall be approved by the Department of Human Resources under rules and regulations adopted by the Commission for Health Services. Recent legislation transfers jurisdiction over all subsurface disposal systems, regardless of size, to the local health departments and the Division for Health Services. Revised rules and regulations pertaining to septic tank installation were promulgated on July 1, 1982.

Coastal Wetlands Activities

This regulation, N.C.G.S. 113-230, allows the Secretary of Natural Resources and Community Development to adopt, modify or repeal orders controlling activities in coastal marshlands and contiguous areas for the purpose of promoting public safety, health and welfare and protecting property, wildlife and marine fisheries. Activities in coastal wetlands that can be affected by such orders include dredging, filling or other alterations such as removal of materials. This statute adds in two significant ways to the state's power to require permits for development in coastal marshlands under dredge and fill regulations. First, the Secretary or his agents may adopt more regulations or guidelines for activities in marshlands rather than reacting to proposed activities on a case-by-case basis. Second, such regulation is explicitly authorized to extend to "designated contiguous areas," thus giving additional geographical jurisdiction. The amount of such contiguous area that can be designated for regulation is limited by the ability to show that such regulation over an area of such size is reasonably necessary to protect the adjacent marshlands. This extension of the regulatory power to contiguous areas offers substantial potential for protecting coastal marshlands from damage due to septic tanks, sedimentation-producing projects and other damaging activities adjacent to but not actually in the marshlands.

Dredge and Fill Permits

A permit must be obtained from the Coastal Resources Commission before dredge and fill activities can begin in estuarine waters, including bays, sounds, rivers, and tributaries seaward of the line dividing coastal and inland fishing waters; tidelands; marshlands, including "any salt marsh or other marsh subject to regular or occasional flooding by tides"; and state-owned lakes, including man-made as well as natural lakes. The state program is coordinated with the U. S. Army Corps of Engineers program. This program covers practically all dredge and fill activities in the marsh and estuarine areas of the coast and is therefore important in protecting coastal wetlands, waters and wildlife.

The Coastal Resources Commission is authorized to let dredge and fill permits. The U.S. Army Corps of Engineers is authorized by 33 U.S.C. 403, the Rivers and Harbors Act, to let permits for dredge and fill activites in navigable waters and by 33 U.S.C. 404 to let permits for discharge of dredged materials into navigable waters, so a permit from the Corps is necessary for dredge and fill activity in navigable waters.

Erosion and Sedimentation Control Plans

N.C.G.S. 113A-54 authorized the establishment of a Sedimentation Control Commission under the Department of Natural Resources and Community Development which promulgates rules and regulations for the control of erosion and sedimentation from land-disturbing activities. The Commission is further charged with developing a local erosion control ordinance and assisting local governments in the development of their ordinances. The Secretary of the Department of Natural Resources and Community Development is responsible for the administration, implementation and enforcement of the Act. The appropriate level of government for this tool was considered to be local, where individual site inspection is feasible if these duties are combined with the administration of other regulatory programs such as subdivision regulation and building permits.

Authority to regulate pursuant to erosion and sediment control plans exists in North Carolina under N.C.G.S. 113A-60 or N.C.G.S. 113A-61. The local ordinances must be at least as strict as the state statute. If the local government does not decide to adopt such ordinances, then the Division of Resource Planning and Evaluation in the Department of Natural Resouces and Community Development shall enforce the state statute.

North Carolina Environmental Policy Act of 1971

The North Carolina Environmental Policy Act is modeled after the National Environmental Policy Act of 1969. Like the federal statute, the State Environmental Policy Act recognizes the value of the human environment and requires state agencies to prepare detailed environmental statements for every "recommendation or report on proposals for legislation and actions involving expenditure of public moneys for projects and programs significantly affecting the quality of the environment of this State" (N.C.G.S. 113A-4(2)).

Authorization for the North Carolina Environmental Policy Act is found in N.C.G.S. 113A-1 to 10. The Act also specifies that copies of environmental statements, together with comments made by agencies with jurisdiction by law or special expertise, be submitted to the Governor, to agencies designated by the Governor, and to multi-county regional agencies, and that they shall follow the North Carolina clearinghouse review process. Copies must also be made available to localities, institutions and the public (N.C.G.S. 113A-4).

The North Carolina Environmental Policy Act could serve as a mechanism for the state government to assert a leadership role in showing other levels of government and the public how coastal ecological processes can be protected through a coordinated public policy. The State has a myriad of programs and policies, ranging from construction of state facilities and roads to protection of marine resources, that directly or indirectly affect the coastal area. The comprehensive nature of the State Environmental Policy Act makes it a potentially important tool in all of the coastal environments. To date, this act has not been implemented, but the development of the Coastal Management Program, under CAMA and Executive Order 15, has provided an opportunity for meeting the intent of this act, at least in the coastal region of North Carolina. (See Section 3.6.1.4.)

3.0 DESCRIPTIONS OF MAN-MADE ENVIRONMENT
3.6 Development Controls
3.6.1 Land Use Regulations
3.6.1.3 Local

LOCAL LAWS DETAIL CONDITIONS RELATING TO PEOPLE'S DAILY NEEDS

Development controls exercised by local governments include zoning, subdivision regulations and building codes. Not all barrier island communities have adopted these types of ordinances.

Local governments typically adopt three main ordinances to regulate land uses in their jurisdictions. Each is described below.

Zoning

Conventional zoning is probably the most commonly employed device for guiding development at the local government level. It is normally used to control the use of land and structures thereon, as well as for more detailed regulation concerning the area of the lot which may be developed (setbacks and separation of structures), the density of the development (minimum lot sizes, etc.) and the height and bulk of buildings and other structures. The general purpose of zoning is to avoid undesirable side effects of development by segregating incompatible uses and by maintaining adequate standards for individual uses.

In North Carolina, authority to zone has been given to municipalities under N.C.G.S. 160A-381 and to counties under N.C.G.S. 153A-340. The zoning power is administered by the elected legislative body of the locality, although certain aspects may be delegated. The permissible purposes for zoning include promoting health and general welfare, preventing overcrowding of land, avoiding undue concentration of population and facilitating adequate public services.

Subdivision Regulations

Subdivision regulations control the process of converting raw land into building sites. They establish standards for public improvements, including streets, drainage pipes, sewer outlets and so forth. These standards may be enforced by requiring the developers to post performance bonds.

Cities have authority to regulate subdivision in North Carolina pursuant to N.C.G.S. 160A-371. The regulations are developed and administered by the local city council, the city council on recommendation of a planning agency, or a designated planning agency. County subdivision regulation is enabled by N.C.G.S. 153A-330 and may be exercised by the Board of County Commissioners or its appointed agency.

A subdivision is defined as "all divisions of a tract or parcel of land into two or more lots, building sites, or other divisions for the purpose of sale or building development (whether immediate or future) and includes all division of land involving the dedication of new street or a change in existing streets."

3.6.1.3 Continued

Building Inspection

All North Carolina cities are authorized to have a building inspection department and must appoint building inspectors, electrical inspectors, plumbing inspectors and other inspectors as appropriate to enforce state and local laws relating to 1) the construction of buildings and other structures, 2) the installation of such facilities as plumbing systems, electrical systems, refrigeration systems and air-conditioning systems, 3) the maintenance of buildings and other structures in a safe, sanitary and healthful condition, and 4) other matters that may be specified by the city council. Counties are also required to establish building inspection departments on a phased basis to be completed by 1985.

The authority for cities to enact building inspection departments is found in N.C.G.S. 160A-411 to 438 and for counites in N.C.G.S. 153A-350 to 375. Coastal communities without a building inspection department, however, are able to qualify for the emergency program of the National Flood Insurance Program through a specially devised flood insurance permit program. This program is separate from the State Building Inspection program and does not fall under the jurisdiction of the State Building Code.

In coastal areas professional competence is especially important because of a number of provisions in the State Building Code that are particularly applicable to coastal areas. All structures built within 150 feet of the ocean, for example, must be constructed on pilings. In addition, the Code spells out precise standards for the size, spacing and means of structural attachment for pilings. The Code also details requirements for areas that are subject to winds of over 121 km (75 mi) per hour. Table 3.6.1.3 shows which local ordinances are in place in coastal counties and selected municipalities.

Table 3.6.1.3 Existing Local Land Development Controls.

Jurisdiction	Zoning Ord.	Subdivision Regulations	Building Codes	Septic Tank Regulations	Erosion & Sediment Control Ord.	Trailer Camp Reg.	Flood Hazard Ord.	Mobile Home Reg.	Water Course Modification Regulation	Environmental Impact Statement Ord.	Federal Flood Ins. Program*
Brunswick County	-	-	X	X	-	-	-	-	-	-	E
Long Beach	X	X	-	X	-	-	X	-	-	-	R
Holden Beach	X	X	-	X	-	-	-	X	-	X	R
Caswell Beach	X	X	-	X	-	-	X	-	-	-	R
Sunset Beach	X	-	-	X	-	-	X	-	-	-	R
Ocean Isle	X	X	-	X	-	-	-	-	-	-	R
Yaupon Beach	X	X	-	X	-	X	-	X	-	-	R
Carteret County	X	X	X	X	-	-	-	X	-	-	R
Emerald Isle	X	X	-	X	X	-	-	-	-	-	R
Pine Knoll Shores	X	X	-	X	-	X	-	X	-	-	R
Atlantic Beach	X	X	-	X	-	-	-	-	-	-	R
Currituck County	X	X	X	X	-	-	-	-	-	-	E
Dare County	X	X	X	X	-	-	X	-	-	-	R
Nags Head	X	X	-	X	X	-	X	-	-	-	R
Kill Devil Hills	X	X	X	X	-	-	-	-	-	-	R
Manteo	-	-	X	X	-	-	-	-	-	-	R
Southern Shores	X	X	X	X	-	-		-	-	-	R
Hyde County	-	-	X	X	-	-	-	-	-	-	E
New Hanover County	-	X	X	X	-	-	-	X	X	-	R
Wrightsville Beach	X	X	-	X	-	-	-	-	-	-	R
Carolina Beach	X	X	-	X	-	-	X	-	-	-	R
Kure Beach	X	-	-	X	-	-	-	-	-	-	E
Onslow County	X	X	X	X	X	-	-	-	X	-	E
Pender County	-	-	X	X	X	X	-	-	-	-	E
Topsail Beach	X	X	-	X	-	-	-	-	-	-	R
Surf City	X	-	-	X	-	X	-	X	-	-	R

*E = Emergency program
R = Regular program

Source: N.C. Coastal Area Management Act Plans

NORTH CAROLINA COASTAL MANAGEMENT PROGRAM
BACKGROUND AND OVERVIEW

North Carolina's Coastal Management Program deserves special attention due to the comprehensive manner in which it addresses the resource use of the coastal region. The focus of the management plan is to integrate a system of land and water management practices at both the state and local level.

The passage of the North Carolina Coastal Area Management Act (CAMA) during the 1974 Session of the General Assembly demonstrated the state's strong and continued interest in protecting its coastal resources. North Carolina's objective in developing a coastal management program is to establish a comprehensive coordinated approach for the protection, preservation, and orderly development of the state's coastal resources. The policy formulation contained in CAMA, although influenced by the national awareness of environmental issues, was motivated primarily by state issues and concerns and proceeded largely independent of federal coastal management efforts.

In recognition of the importance of the coastal zone of the United States, Congress passed the Coastal Zone Management Act (P.L. 92-582) which was signed into law on October 27, 1972. The Act authorized a federal grant-in-aid program to be administered by the Secretary of Commerce, who in turn delegated this responsibility to the National Oceanic and Atmospheric Administration's (NOAA) Office of Coastal Management (OCZM). In July of 1976, the Coastal Zone Management Act of 1972 was substantially amended (P.L. 94-370). The Act and 1976 amendments affirm a national interest in the effective protection and development of the coastal zone by providing assistance and encouragement to coastal states to develop and implement rational programs for managing their coastal zones.

In North Carolina, federal, state, county, and local governments all influence the use of the coastal area. Resource management activities are distributed among different state agencies, as well as different levels of government. These lines of responsibilities cover all aspects of environmental management, from controlling destruction of sand dunes to regulating the placement of septic tank absorption fields. In 1977, Governor Hunt signed Executive Order 15 mandating state agency consistency with the local land use plans and the North Carolina Coastal Management Plan (CMP).

Executive Order 15 provided the framework of communication among local, state, and national levels that allowed an integrated and thorough procedure for managing coastal resource use. The North Carolina CMP established several modes for policy expression including the State Guidelines, the local land use plans required by the Coastal Area Management Act, and the State Coastal Management Plan. The State Guidelines contain policies adopted by the Coastal Resources Commission that serve as the framework for the development of the local land use plans, establish the standards for Areas of Environmental Concern and represent the overall state policy on coastal issues.

The local land use plans further define these state policies by applying the policies contained in the Guidelines to local situations and circumstances.

The State Guidelines stated that every local land use plan should include a land classification system and set forth the policies for that system. Briefly, the North Carolina land classification system contains five classes of land: conservation, rural, community, transition and developed. These five classes provide a framework to be used by local governments to identify the general use of all lands in each county. Such a system presents an opportunity for the local government to provide for its needs as well as to consider those of the whole state. This system also allows local governments to make a statement of policy regarding the location and density of growth and to conserve the jurisdiction's natural resources by guiding growth. In the current five year update of the land use plans, 52 local jurisdictions are developing policies to further refine the communities' development goals.

Consistency of local actions with state policies is promoted through this planning arrangement because of the required approval of the local plans by the Coastal Resources Commission. The North Carolina Coastal Management Plan incorporates the policies from both the Guidelines and the land use plans, as well as other state coastal policies (U.S. Dept. of Commerce 1978).

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.6 Development Controls

3.6.1 Land Use Regulations

3.6.1.4 North Carolina Coastal Management Program

3.6.1.4.1 Determination of Direct and Significant Impact Areas

DEFINITION OF DIRECT AND SIGNIFICANT IMPACT

Proximity to coastal water and magnitude and type of use were identified as the primary factors in determining which uses demanded additional attention in the coastal counties. Various issues ranging from environmental conservation to institutional management were considered to comprehensively administer an integrated resource program in coastal North Carolina.

The primary objective of North Carolina's coastal management efforts was to provide a system capable of insuring the orderly use and preservation of its coastal resources for the people of North Carolina and for the nation. Achievement of this objective was possible only if the management of land and water uses having direct and significant impacts on important coastal resources could be coordinated. Consequently, the first task in designing the coastal management program was to define uses having a direct and significant impact on its coastal resources. These defined uses were then used to establish the degree and breadth of control necessary for the management program.

Determination of uses that are to be managed could not simply be summed up by listing major uses having impacts on coastal resources. Rather, it was recognized by the North Carolina program that it was more proper to use two major criteria to determine the potential impact of any given activity: the location of the use in relation to coastal waters and the character of the use. That is, there are certain areas in the coastal zone in which almost any use has the potential to affect directly coastal waters while in other areas only large scale activities significantly affect coastal waters. Thus, in planning an approach to the management of uses with significant impact on coastal resources, North Carolina realized that varying levels of control were desirable. Therefore, a two-tier system was developed to manage desired levels of control in the coastal zone. The first tier contains all the Areas of Environmental Concern (Section 3.6.1.4.3). The second tier contains the critical uses (Section 3.6.1.4.5).

All of the following activities can cause direct and significant impacts in the coastal zone. These issues are addressed by the CMP.

1) Growth Management
    a. key facilities
    b. conflicting land uses
    c. residential and second home development

2) Coastal Industry
    a. fishing and seafood

3.6.1.4.1 Continued

- b. agriculture and forestry
- c. mining
- d. manufacturing

3) Transportation
   - a. highways, roads, and related facilities
   - b. ports
   - c. navigation

4) Tourism and Recreational Resources
   - a. recreation
   - b. tourism
   - c. unique cultural and natural resources
   - d. beach access

5) Energy Issues
   - a. energy generating facilities
   - b. petroleum refineries
   - c. Outer Continental Shelf development
   - d. Peat development
   - e. Coal port development

6) Environmental Issues
   - a. waste disposal
   - b. water supplies
   - c. development in coastal hazard areas
   - d. drainage
   - e. dredging and spoil disposal
   - f. coastal wetlands preservation
   - g. protection of unique environments

7) Institutional Arrangements
   - a. public participation
   - b. local and state cooperation
   - c. federal consistency
   - d. uses of regional benefit
   - e. state agency consistency
   - f. permit coordination

3.6.1.4.2 CAMA Jurisdiction

TWENTY COASTAL COUNTIES INCLUDED IN MANAGEMENT AREA

In order to administer the CMP in an equitable and politically consistent manner, 20 counties were included to control direct and significant impacts on coastal waters.

The North Carolina coastal zone exhibits a gradual transition from land to sea dominated by rivers, estuaries and bays. The entire coastal environment is influenced by and intimately linked to the vast estuary areas. The extent of the coastal plain extends many miles inland from the boundaries of the coastal area. Although land use activities in the upper coastal plain, as well as the piedmont and mountains, affect coastal resources, the impacts of such activity are less direct and significant than the impacts resulting from development occurring directly within the coastal area.

The North Carolina coastal area is defined in Section 113A-103(2) of CAMA as "the counties that (in whole or in part) are adjacent to, adjoining, intersected by or bounded by the Atlantic Ocean (extending offshore to the limits of state jurisdiction, as may be identified by rule of the Commission for purposes of this article, but in no event less than three geographical miles offshore) or any coastal sounds." The limits of Coastal Resources Commission authority do not extend beyond the current offshore state jurisdiction as defined by the federal government.

The state identified 20 counties as comprising the coastal area in response to the federal Coastal Zone Management Act, Section 304a, which required a state to include those lands "necessary to control the shorelands, the uses of which have a direct and significant impact on the coastal waters." These counties are Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Gates, Hertford, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Tyrrell, and Washington. (Figure 3.6.1.4.2) is a map showing the location of these counties.

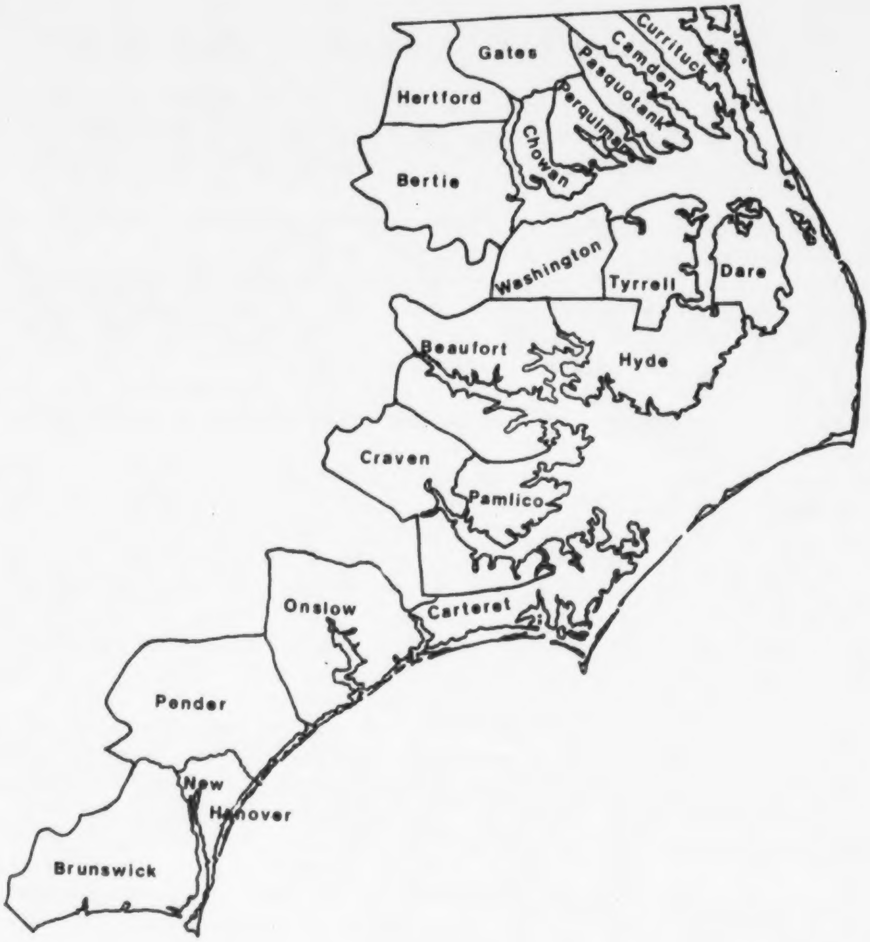

Gates
Currituck
Camden
Pasquotank
Hertford
Perquimans
Chowan
Bertie
Washington
Tyrrell
Dare
Beaufort
Hyde
Craven
Pamlico
Onslow
Carteret
Pender
New Hanover
Brunswick

Figure 3.6.1.4.2 Map of North Carolina Coastal Zone
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources and Community Development

3.6.1.4.3 Areas of Environmental Concern

MANAGEMENT IN THE FIRST TIER: AREAS OF ENVIRONMENTAL CONCERN

Areas critical to the functioning of natural coastal processes have been identified for special regulatory consideration. When development is proposed in these areas appropriate standards must be considered, except in a few exempted cases. Fourteen Areas of Environmental Concern have been delineated.

The critical areas in the North Carolina coastal zone are identified as Areas of Environmental Concern (AEC) under authority of the Coastal Area Management Act (CAMA). In combination, these areas comprise the First Tier, which is the more thoroughly regulated area in North Carolina's coastal zone. The Coastal Resources Commission has determined which types of areas should be presently designated as AECs and has established standards for development in those areas. All but a few exempted activites must receive a permit to develop in these areas.

All of the AECs combine to create a zone that includes all estuarine waters and coastal wetlands and a narrow buffer zone of land around them. This zone is the area where strictest regulation is deemed necessary and therefore, where the most thorough regulatory process (the CAMA permit letting process) applies to practically all development.

The CMP controls most construction activities which occur in the AECs but certain activities do not fall under the permit process:

- Highway maintenance on existing rights-of-way
- Railroad and utility maintenance and upgrading on existing property
- Utility construction covered by the State Utilities Commission
- Agricultural purposes, except those affecting estuarine and navigable waters by excavation or filling
- Emergency maintenance
- Construction of accessory building to existing structures
- Developments which received building permits, zoning permits, subdivision approval and all other permits prior to ratification of CAMA
- Developments with pending zoning or building permits and approved loans made prior to approval of CAMA

3.6.1.4.3 Continued

The four major AEC classifications are Estuarine System, Ocean Hazard Areas, Public Water Supplies and the Natural and Cultural Resource Areas (see Figure 3.6.1.4.3.a). These classifications contain 14 subcategories.

ESTUARINE SYSTEM

Included within the estuarine system are the following AEC categories: Estuarine Waters, Coastal Wetlands, Public Trust Areas and Estuarine Shorelines. Each of these AECs is either geographically within the estuary or, because of its location and nature, may significantly affect the estuary (see Figure 3.6.1.4.3.b). The following sections define each AEC within the estuarine system, describes its significance and expresses the priority of uses for each AEC.

1. AEC Coastal Wetlands

Description--Coastal Wetlands are considered to be those marshes that are subject to regular or occasional flooding by tides, including normal wind tides. Certain vegetative species are included in the technical definition as indicators of the frequency of flooding.

Significance--Coastal Wetlands provide plant materials (detritus) that form the basis for the complex food chain of the estuary. Marshes also supply good quality nesting, feeding and refuge areas for waterfowl and wildlife; serve as an erosion buffer for upland areas; act as an effective nutrient and sediment trap; and provide the coast with a unique and pleasant landscape.

Priority of Use--Highest priority of use shall be allocated to the conservation of existing coastal wetlands. Second priority shall be given to those types of development activities that require water access and cannot function elsewhere. Lowest priority will include restaurants and businesses; residences, apartments, motels, hotels and trailer parks; parking lots and offices; spoil and dump sites; wastewater lagoons; public and private roads and highways; and factories.

2. AEC Estuarine Waters

Description--Estuarine Waters are all the waters of the bays, sounds, rivers and their tributaries seaward of a line that separates coastal from inland fishing waters.

Significance--Estuarine-dependent species of fish and shellfish currently make up over 90 percent of the total value of North Carolina's commercial catch. Estuarine waters are also a source of economic benefit to the coast resulting from waterfowl hunting, marinas, boatyards, marine repairs and supplies, fish processing operations, tourism, commercial navigation and recreation.

Priority of Use--Highest priority of use shall be allocated to the conservation of estuarine waters and their vital components. Uses of second

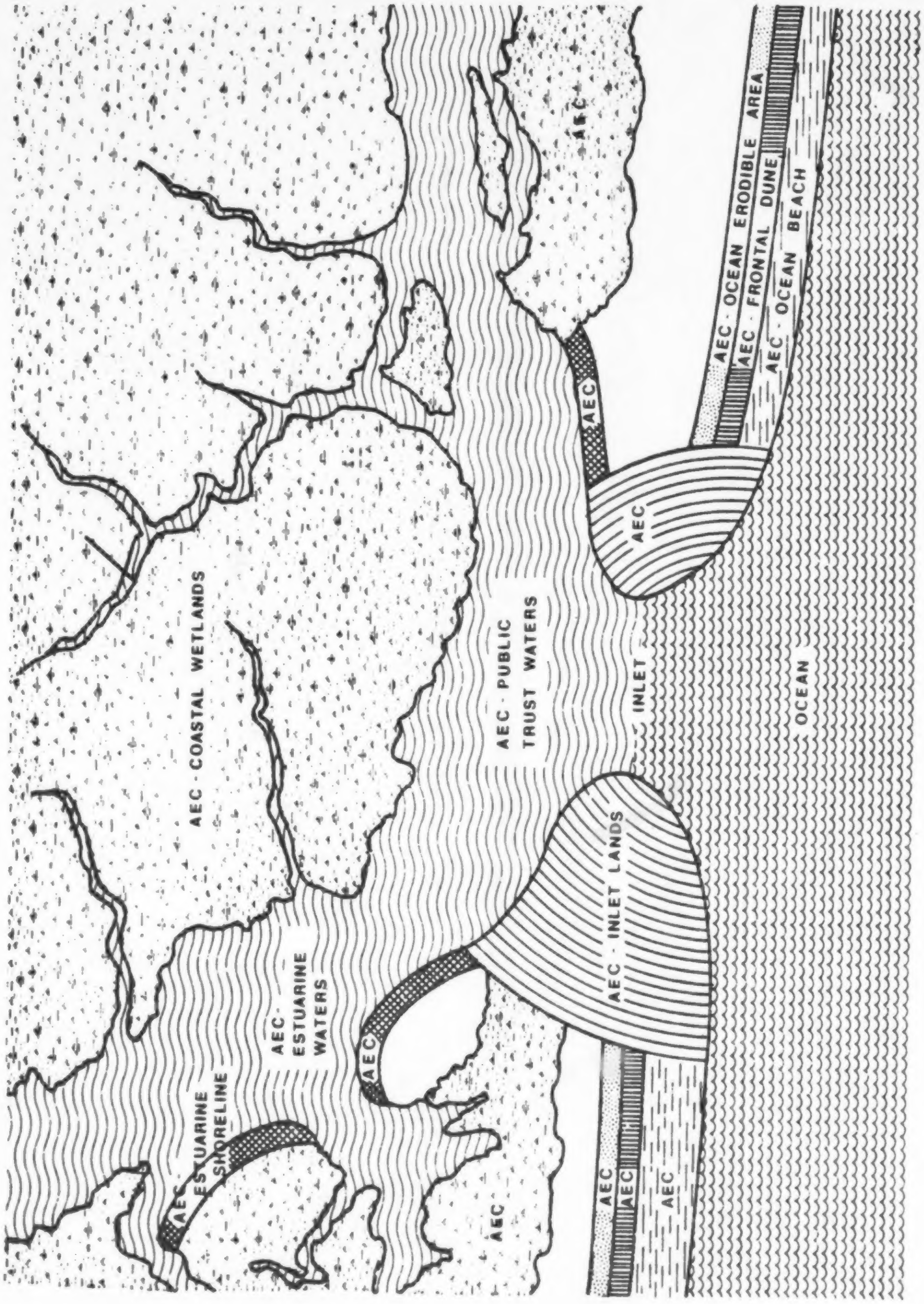

AEC · COASTAL WETLANDS
AEC · PUBLIC TRUST WATERS
INLET
OCEAN
AEC · ESTUARINE WATERS
AEC · ESTUARINE SHORELINE
AEC · INLET LANDS
AEC · OCEAN ERODIBLE AREA
AEC · FRONTAL DUNE
AEC · OCEAN BEACH
AEC
AEC
AEC
AEC
AEC
AEC
AEC

Figure 3.6.1.4.3.a Generalized Description of Areas of Environmental Concern
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources and Community Development

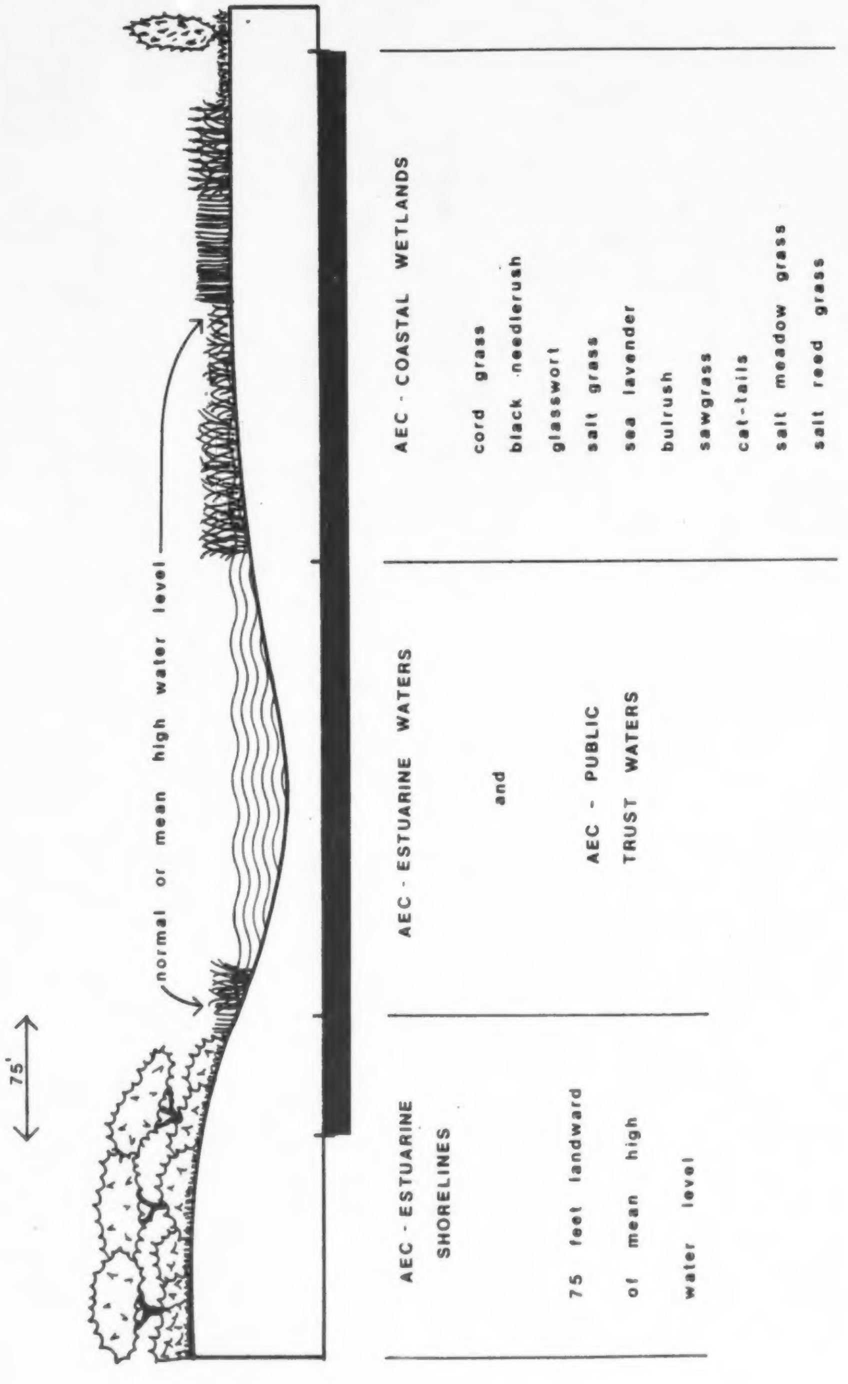

AEC - ESTUARINE SHORELINES
75 feet landward of mean high water level
75'
normal or mean high water level
AEC - ESTUARINE WATERS
and
AEC - PUBLIC TRUST WATERS
AEC - COASTAL WETLANDS
cord grass
black needlerush
glasswort
salt grass
sea lavender
bulrush
sawgrass
cat-tails
salt meadow grass
salt reed grass

Figure 3.6.1.4.3.b Areas of Environemntal Concern--Estuarine System
Source: U.S. Department of Commerce
N.C. Department of Natural Resources and Community Development

priority in estuarine waters shall include those types of development activities that require water access such as simple access channels; structures to prevent erosion; navigation channels; and boat docks, piers, wharfs, and mooring pilings. Lowest priority is allocated to those uses that would adversely impact important marine grass beds; spawning and nursery areas of valuable estuarine dependent species; or important nesting, feeding, and wintering sites of waterfowl and wildlife.

3. AEC - Public Trust Areas

Description--Public trust areas are all waters in the coastal zone in which the public has acquired rights by prescription, custom, usage, dedication or any other means. Public Trust Areas include, in addition to Estuarine Waters, certain water bodies within the coastal zone that are inland from Estuarine Waters.

Significance--The public has rights in these areas, including navigation and recreation that need protection. In addition, these waters support valuable commercial and sports fisheries, have aesthetic value and are important potential resources for economic development.

Priority of Use--High priority will be allocated to uses that enhance the rights of the public within public trust areas. Second priority will be given to navigational channels, drainage ditches, the use of bulkheads to prevent erosion and the building of piers, wharfs, or marinas. Lowest priority is given to projects which would directly or indirectly block or impair existing navigation channels, increase shoreline erosion, deposit spoils below mean high tide, cuase adverse water circulation patterns, violate water quality standards or cause degradation of shellfish waters.

4. AEC Estuarine Shorelines

Description--Estuarine shorelines are the fastlands adjacent to estuarine waters extending landward 22.9 m (75 ft)from mean high water or normal high water.

Significance--Development within the estuarine shorelines of AECs influences the quality of the estuarine system and is subject to the damaging processes of shore front erosion and flooding.

Priority of Use--Highest priority of use shall be allocated to recreational, rural and conservation activities in those shoreline areas exhibiting a significant erosion rate. High priority shall also be given to water access and shoreline protection, provided that public resources will not be detrimentally affected. Second priority of land use shall be given to proposals which illustrate a sound understanding of the management principles of this dynamic and susceptible zone. Lowest priority shall be allocated to major public facilities that would promote growth in areas where a substantial possibility of excessive public expenditures for maintaining the use of the facility may result or the facility would result in a loss of significant private resources. Proposed development that may harm estuarine resources or cause damage to riparian properties will also receive lowest priority.

3.6.1.4.3 Continued

OCEAN HAZARD AREAS

The next grouping is composed of those AECs that are considered natural hazard areas along the Atlantic Ocean shoreline where, because of their special vulnerability to erosion or other adverse effects of sand, wind, and water, uncontrolled or incompatible development could unreasonably endanger life or property. Ocean hazard areas include lands containing beaches, dunes, inlets, areas susceptible to wave attack and other areas in which geologic, vegetative and soil conditions indicate a substantial possibility of excessive erosion or flood damage.

The following sections define each AEC within the ocean hazard area, describe briefly its significance and outline the respective priority of uses.

5. AEC-Inlet Hazard Areas

Description--Inlet hazard areas are lands adjacent to inlets having demonstrated a tendency or a probability of migrating along the Outer Banks. The AEC is defined using the past history of the inlet to predict possible future movements of the inlet. As seen in Figure 3.6.1.4.3.c the Inlet Hazard Areas include those lands that have either eroded within the past 25 years or that are predicted to erode in the future. Predictions were calculated through the use of demonstrated erosion rates (Priddy and Carraway 1978).

Significance--The location of an inlet is often a temporary one; such channels often are subject to extensive migration. Coastal inlet lands are therefore extremely dynamic land areas that are highly susceptible to becoming completely displaced by water.

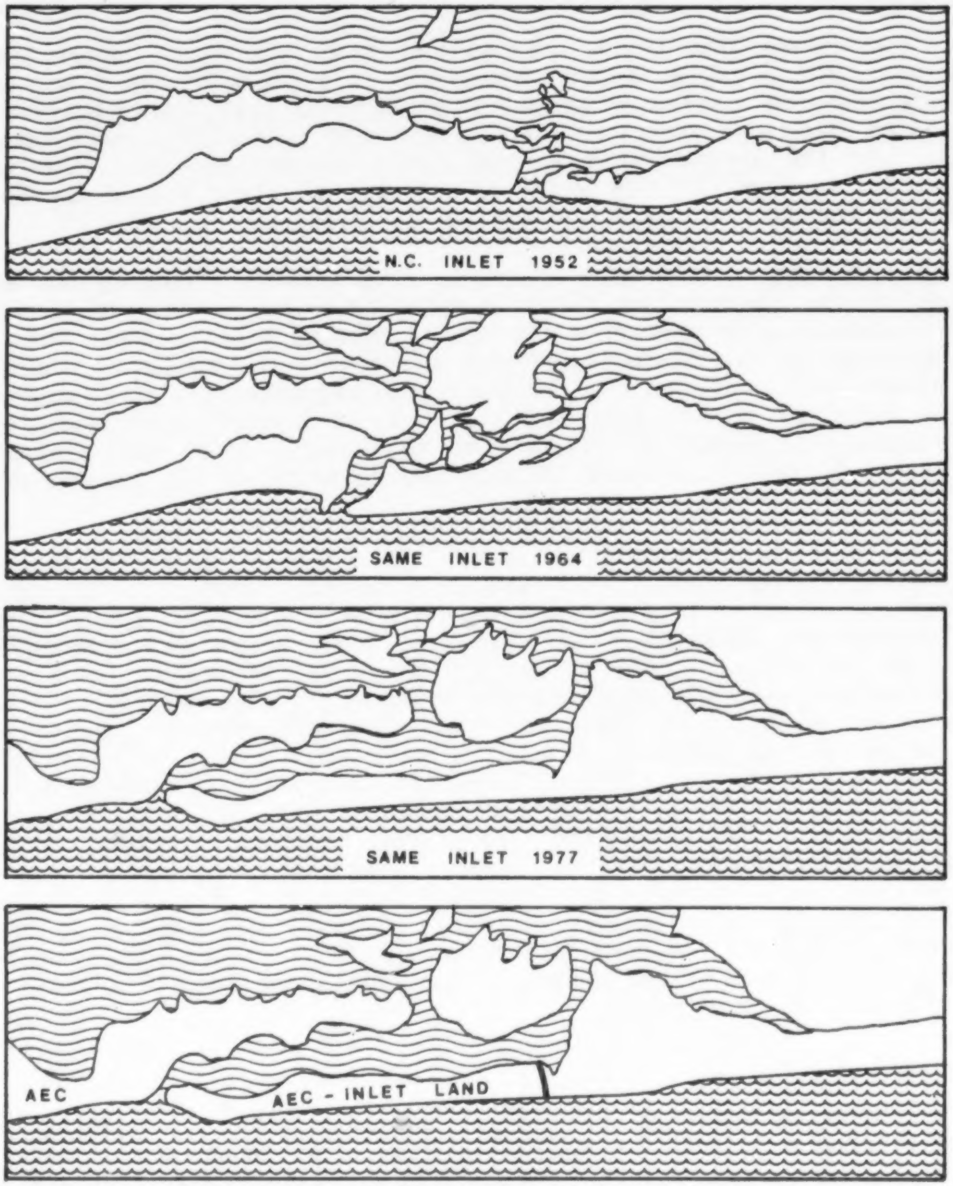
Priority of Use--Highest priority shall be given to uses that do not involve the construction of substantial structures. Lowest priority will be allocated to major public facilities.

6. AEC-Ocean Erodible Areas

Description--Ocean Erodible Areas are ocean shoreline areas that have been idenitifed by the State Geologist as hazardous to development because of excessive erosion. The Ocean Erodible Area overlays the Frontal Dune and is based on a calculated distance landward from the first line of stable natural vegetation. The distances landward used in this description are usually based on studies of the probable erosion resulting from a storm surge of a 100 year frequency, plus a distance equal to erosion expected over a 30 year period.

Significance--Ocean Erodible Areas are extremely dynamic lands, highly susceptible to becoming displaced by periodic storm surges.

Priority of Use--Highest priority shall be allocated to recreational and other non-structural uses. Lowest priority shall be given to structures for commercial or institutional purposes that encourage growth in these hazardous areas.


N.C. INLET 1952
SAME INLET 1964
SAME INLET 1977
AEC
AEC - INLET LAND

AEC - INLET LANDS - areas most likely to erode in the next 25 years, based on records of past inlet migration.

Figure 3.6.1.4.3.c Areas of Environmental Concern--Inlet Lands
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources and Community Development

3.6.1.4.3 Continued

7. AEC-High Hazard Flood Area

Description--This is the area subject to high velocity waters (including, but not limited to, hurricane wave wash) in a storm having a one percent chance of being equaled or exceeded in any given year, as identified as zone V1-30 on the flood insurance rate maps of the Federal Insurance Administration. In the absence of these rate maps, other available base flood elevation data prepared by a federal, state, or other source may be used, provided the data source is approved by the CRC.

Significance--The primary causes of the hazards affecting the Atlantic shoreline are the constant forces exerted by waves, winds, and currents upon the unstable sands that form the shore. During storms, these forces are intensified and can cause significant changes in the bordering landforms and to structures located on them. Hazard area property is in the ownership of a large number of private individuals as well as several public agencies and is used by a vast number of visitors to the coast. Ocean hazard areas are critical, therefore, because of both the severity of the hazards and the intensity of interest in the areas.

The location and form of the various hazard area landforms, in particular the beaches, dunes, and inlets, are in a permanent state of flux, responding to meteorologically induced changes in the wave climate. For this reason, the appropriate location of structures on and near these landforms must be reviewed carefully in order to avoid their losses or damage. As a whole, the same flexible nature of these landforms which presents hazards to development offers protection to the land, water and structures located landward of them. The value of each landform lies in the particular role it plays in affording protection to life and property. Overall, however, the energy dissipation and sand storage capacities of the landforms are most essential for the maintenance of the landforms' protective function. (North Carolina Administrative Code, Chapter 7H, Section .0304).

Priority of Use--Highest priority is given to uses that do not restrict the flow of flood water through this area. Lowest priority is given to development that retards flood waters or stabilizes the natural systems which respond to flood occurrences.

PUBLIC WATER SUPPLIES

Public water supplies as a broad category includes two AECs: Small Surface Water Supply Watersheds and Public Water Supply Well Fields. The following discussion includes the description, significance, and the priority of uses for each.

8. AEC-Small Surface Water Supply Watersheds

Description--These catchment areas contain freshwater streams that are of the highest quality in the coastal zone. They require a minimum amount of treatment in order to serve as potable water. The first pond between Kill Devil Hills and Nags Head is the only barrier island resource in this category.

3.6.1.4.3 Continued

Significance--These critical water supplies, if degraded, could adversely affect public health or require substantial monetary outlays for alternative water source development.

Priority of Use--Highest priority shall be allocated to non-intensive recreational uses. Lowest priority will be given to major land disturbing activities or development that has a possibility of introducing pollutants into the surface waters.

9. AEC-Public Water Supply Well Fields

Description--This AEC includes those well fields judged to be critical as a public water supply by the North Carolina Division of Health Services. This includes one site on the barrier islands, the Cape Hatteras Water Association well field on Hatteras Island.

Significance--The area, unless protected, could be subjected to development that could adversely effect water quality or quantity. This situation would result in a significant loss of public resources.

Priority of Use--Highest priority shall be allocated to non-intensive uses that offer no threat to water quality such as green spaces, parks, athletic fields and other non-intensive uses. Lowest priority is given to development that requires construction of permanent structures or other impervious surfaces.

NATURAL AND CULTURAL RESOURCE AREAS

The fourth and final group of AECs is gathered under the heading of Fragile Coastal Natural Resource Areas and is defined as areas containing environmental or natural resources of more than local significance in which uncontrolled or incompatible development could result in major or irreversible damage to natural systems, scientific or educational values, or aesthetic qualities. Five AECs are encompassed in this category: Unique Coastal Geologic Formations, Coastal Complex Natural Areas, Coastal Areas That Sustain Remnant Species, Significant Coastal Archeological Resources, and Significant Coastal Historic Architectural Resources.

Nomination of Sites--The designation of a Coastal Complex Natural Area, a Unique Coastal Geologic Formation, or a Coastal Area that Sustains a Remnant Species is a process peculiar to these categories of AECs alone. Unlike the other AECs, designation is based upon a procedure of nomination, evaluation, and site specific designation.

Priority of Use--Highest priority shall be given to uses that preserve the natural character of the AEC. Lowest priority is given to uses that involve the disturbance of natural vegetation or animal life or increase uncontrolled access to the site.

10. AEC-Unique Coastal Geologic Formations

Description--Unique Coastal Geologic Formations are defined as sites that contain formations that are unique or otherwise significant components of coastal systems or are especially notable examples of geologic formations or processes in the coastal area. Such areas will be evaluated by the Commission after identification by the State Geologist.

Significance--Unique Coastal Geologic Areas are important educational, scientific or scenic resources that would be jeopardized by uncontrolled or incompatible development.

Priority of Use--Highest priority is allocated to uses that enhance the educational and scientific importance of the site. Lowest priority is given to uses that adversely impact the site.

11. AEC-Coastal Areas that Sustain Remnant Species

Description--Coastal Areas That Sustain Remnant Species are those areas that support native plants or animals determined to be rare or endangered (synonymous with threatened and endangered), within the coastal area. Such places provide habitats necessary for the survival of existing populations of rare or endangered species within the coastal area. Determination will be made by the Commission based upon the listing adopted by the North Carolina Wildlife Resources Commission or the federal government listing; upon written reports or testimony of experts indicating that a species is rare or endangered within the coastal area; and upon consideration of written testimony of local government officials, interest groups and private land owners.

Significance--The continued survival of certain habitats that support native plant and animals in the coastal area is vital for the preservation of our natural heritage and for the protection of natural diversity which is related to biological stability. These habitats and the species they support provide a valuable educational and scientific resource that cannot be duplicated.

Management Objective--To protect unique habitat conditions that are necessary to the continued survival of threatened and endangered native plants and animals and to minimize land use impacts that might jeopardize these conditions.

12. AEC-Coastal Complex Natural Areas

Description--Coastal Complex Natural Areas are defined as lands that support native plant and animal communities and provide habitat qualities which have remained essentially unchanged by human activity. Such areas may be either significant components of coastal systems or especially notable habitat areas of scientific, educational or aesthetic value. They may be surrounded by landscape that has been modified but does not drastically alter conditions within the natural area.

Significance--Coastal Complex Natural Areas function as key biological components of natural systems, as important scientific and educational sites, or as valuable scenic or cultural resources. Often these natural areas provide habitat suitable for threatened or endangered species or support plant and animal communities representative of pre-settlement conditions. These areas help provide a historical perspective to changing natural habitats in the coastal area and together are important and irreplaceable scientific and educational resources.

Management Objectives--To protect the features of a designated Coastal Complex Natural Area in order to safeguard its biological relationships, educational and scientific values and aesthetic qualities (N.C. Administrative Code, Chapt. 7H, Section .0500).

13. AEC-Significant Coastal Archeological Resources

Description--Significant Coastal Archeological Resources are defined as areas that contain archeological remains (objects, features and/or sites) that have more than local significance to history or prehistory. Such areas will be evaluated by the North Carolina Historical Commission in consultation with the CRC.

Significance--Significant Coastal Archeological Resources are important educational, scientific or aesthetic resources. Such resources would be jeoparidized by uncontrolled or incompatible development. In general, significant archeological resources possess integrity of location, design, setting, workmanship, materials and association. These resources are associated with events that have made a significant contribution to the broad patterns of history or are associated with the lives of persons significant in history. They embody the distinctive characteristics of a type, period, or method of construction, or represent a significant and distinguishable entity whose components may lack individual distinction. Such sites have yielded, or may be likely to yield, information important in history or prehistory.

Management Objectives--The CRC's objective is to conserve coastal archeological resources of more than local significance to history or prehistory that constitute important scientific sites or are valuable educational, associative or aesthetic resources.

14. AEC-Significant Coastal Historic Architectural Resources

Description--Significant Coastal Historic Architectural Resources are important educational, scientific, associative, or aesthetic resources. Such resources would be jeopardized by uncontrolled or incompatible development.

Significance--Significant Coastal Archeological Resources are important educational, scientific or aesthetic resources. Such resources would be jeoparidized by uncontrolled or incompatible development. In general, significant archeological resources possess integrity of location, design, setting, workmanship, materials and association. These resources are associated with events that have made a significant contribution to the broad patterns of history or are associated with the lives of persons significant in history. They embody the distinctive characteristics of a type, period, or method of construction, or represent a significant and distinguishable entity whose components may lack individual distinction. Such sites have

3.6.1.4.3 Continued

yielded, or may be likely to yield, information important in history or prehistory.

Management Objectives--The CRC's objective is to conserve coastal archeological resources of more than local significance to history or prehistory that constitute important scientific sites or are valuable educational, associative or aesthetic resources.

3.6.1.4.4 AEC Permitting

AEC PERMITTING IS THE RESPONSIBILITY OF STATE AND LOCAL GOVERNMENT

The state CRC is responsible for issuing permits for major developments. Once a locality has a plan and enforcement program approved by the CRC, the local authority may issue permits for minor developments.

The authority to designate AECs rests exclusively with the CRC. However, once these areas are designated, the authority for administering the CAMA permit program is shared between the CRC and local government units within the coastal area. The CAMA provides that "each county and city within the coastal area shall submit to the Commission a written statement of its intent to act or not to act as a permit-letting agency...." Upon presenting to the Commission and having approved a plan for a local implementation and enforcement program, any county or city that has submitted such a request receives authorization to process applications for minor development permits in AECs. All of the 20 counties and all but two of the eligible municipalities have chosen to institute such administrative responsibility. The Commission retains responsibility for processing applications for major development permits and hearing appeals of local decisions concerning minor development applications.

Therefore, in order to understand which permits will be handled locally and which will be handled by the Commission, it is necessary to distinguish between major and minor development. Major development is any development that requires the authorization, permission, certification, approval, or licensing of another state agency; or will occupy a land or water area in excess of 8.1 ha (20 ac); or which occupies on a single parcel a structure or structures in excess of a ground area of 5574 m^2 (60,000 ft^2); or the siting of a utility facility that is not subject to the authority of the State Utilities Commission. Any other development is considered minor.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.6 Development Controls

3.6.1 Land Use Regulations

3.6.1.4 North Carolina Coastal Management Program

3.6.1.4.5 CAMA Critical Uses

MANAGEMENT IN THE SECOND TIER TAKES PLACE OUTSIDE AECS

Critical uses, determined by the type and size of the development, will be regulated by existing laws and regulations in the coastal zone outside the Areas of Environmental Concern.

In the coastal areas outside AECs, the Coastal Management Program relies on a more limited state role. The state is involved in decision-making in non-AEC areas only where uses and activities which have a potential for directly and significantly affecting coastal resources are proposed. Such uses and activities are referred to as Critical Uses. Statutes and regulations which are already in force in North Carolina provide the state with the authority to make decisions regarding these critical uses.

The second part of North Carolina's definition of direct and significant impact is based on the type of activity and the size of the development. Thus, the state has identified critical uses that have the potential to affect coastal waters even though they are not located in the AECs. In determining such potential for direct and significant impact, consideration was given to such factors as the nature of the process or activities involved; the residuals generated; the tendency of the type of project to induce further development; and the size of the development.

The level of control is less intensive in this second tier and management is directed only to uses that have recognized significant impacts. This control was effected through existing regulatory programs and through management tools established specifically for coastal management (U.S. Dept. of Commerce 1978).

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT
3.6 Development Controls
3.6.1 Land Use Regulations
3.6.1.4 North Carolina Coastal Management Program
3.6.1.4.6 Administrative Coordination

NETWORKING - KEY TO AN INTEGRATED STATE AND LOCAL MANAGEMENT PARTNERSHIP

Existing statutes and regulations have been combined with CAMA and Executive Order 15 to institute a comprehensive network of management techniques with which to consider proposed coastal development.

North Carolina has developed an extensive array of statutory programs which allow the state to influence the impacts of certain types of development considered potentially damaging to natural resources. This composite of authorites is divided into two categories, which are differentiated based on the type of role that the particular authority allows the state to play. The two categories of authorities are authorities that allow regulation, primarily of private uses, and authorities that affect government or government financed activities (state, local, and federal) through controls of acquisition, spending, planning and review of projects.

The following matrix (Figure 3.6.1.4.6) identifies the authorities (regulations) that are applicable to each of the critical (permissible) uses included under North Carolina's management plan. The critical uses are listed in the vertical column on the left, and the authorities are listed in the horizontal column across the top. "X"s mark the authorities that apply to each critical use. Several of the authorities are applied to certain types of areas, rather than specific uses. Therefore, all uses in those certain areas are subject to regulation unless they are exempted by the authorizing legislation or agency regulations. The most important of these regulated areas are capacity use areas, floodways, sand dune protection areas, and wetlands subject to dredge and fill regulations (U.S. Dept. of Commerce 1978).

NORTH CAROLINA AUTHORITIES TO CRITICAL USES

ADMINISTERING AGENCY	Department of Natural Resources and Community Development																							Dept. of Administration			Dept. of Agriculture	Dept. of Commerce	
	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DMF	DMF	DMF	DMF	DLR	DLR	DLR	DLR	DPR	DPR	DPR	DPR								
STATUTORY AUTHORITY (G.S. CITATION)	143-215.1	143-215.11	143-215.39	143-215.51	143-215.75	143-215.105	87-87	162A-20	162A-26	143-355	113-229	113-230	113-201	113-205	143-215.23	74-48	113-381	113A-50	113-34 et. seq.	113A-30	113A-83	113-29 et. seq.		143B – 437	146-6 (c)	146-3 et. seq.	146-22.1	143-434	62-110	143-217
AUTHORITIES / CRITICAL USES	Water Quality Control Statutes	Water Use Act	Federal Water Resources Development Act	Floodway Regulation	Oil Pollution Control Act	Air Quality Statutes	Well Construction Act	Regional Water Supply Planning Act	Regional Sewage Disposal Planning Act	Development & Improvement of Harbors	Dredge & Fill Act	Wetland Production Orders	Fisheries Statutes	Registration of Grants in Navigable Waters	Dam Construction Act	Mining Act	Oil & Gas Conservation Act	Sedimentation Pollution Control Act	Acquisition and Management of State Parks	Natural & Scenic Rivers Act	N.C. Trails System Act	Acquisition & Development of State Forests		Investigation of Impact of New & Expanded Industry	Easements To Fill	Easements, Leases, Sale of State Land	Acquisition of Land for Public Purposes	Pesticide Application	Public Utilities Act	State Ports Authority
Petroleum Refineries	X			X	X	X					X	X					X	X						X	X					
Energy Generating Facilities	X			X		X					X	X					X	X						X	X				X	
Oil and Gas Wells	X			X	X	X	X				X	X					X	X							X	X				
Mining Operations	X	X		X		X	X				X	X				X								X	X	X				
Major Petroleum Storage Sites	X			X	X						X	X					X	X							X					
State Roads											X	X						X							X	X				
Bridges											X	X						X							X	X				
Commercial Ports	X		X		X	X				X	X	X						X						X	X	X				X
Navigation Projects	X		X								X	X		X																
Industrial Parks	X			X		X					X	X						X						X						
Shopping Centers	X			X							X	X						X						X						
Large Subdivisions	X			X		X					X	X						X												
High Rise Apts. or Hotels	X			X							X	X						X												
Manufacturing Facilities	X			X		X					X	X						X						X						
Livestock Feedlot Operations	X										X	X																		
Pesticide Use																												X		
Large Drainage Operations	X										X	X																		
Large Water Wells	X	X					X	X			X	X																		
Sewage Treatment Facilities	X								X		X	X						X												
Public Drinking Water Supplies		X					X	X			X	X																		
Solid Waste Disposal Sites						X					X	X						X							X					
Large Marinas	X		X								X	X													X					
State Parks											X	X							X	X	X					X	X			
State Forests																				X	X	X				X	X			
Preservation of Natural and Scenic Rivers																			X	X										
Preservation of Historic Properties																			X								X			
Public Accessways											X	X														X	X			
Large Dams			X								X	X			X											X				
Commercial Fishing												X	X																	

			Dept. of Adminis tration			Dept. of Agriculture	Dept. of Commerce		Dept. of Cultural Resources	Dept. of Human Resources			Dept. of Transpor-tation			DMF
et. seq.		143B – 437	146-6 (c)	146-3 et. seq.	146-22.1	143-434	62-110	143-217	121-9	130-166.22	130-166.17	130.161.1	136-44.1	136-66.2	136-122	113-251
of State Forests		Investigation of Impact of New & Expanded Industry	Easements To Fill	Easements, Leases, Sale of State Land	Acquisition of Land for Public Purposes	Pesticide Application	Public Utilities Act	State Ports Authority	Acquisition & Management of Historic Properties	Ground Absorption Sewage Disposal Act	Solid Waste Disposal Act	Sewer & Sanitation Act	Highway Safety Act	Streets & Highways in and Around Municipalities	Roadside Advertising	Atlantic States Marine Fisheries Compact
		X	X													
		X	X				X									
			X	X												
		X	X	X												
			X													
			X	X									X	X	X	
			X	X												
		X	X	X				X								
		X								X	X	X				
		X								X	X	X				
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			X								X					
			X							X	X					
				X	X											
X				X	X											
					X				X							
				X	X											
				X												
																X

KEY TO SYMBOLS:
(Abbreviations represent Division with Dept. of NR & CD)
Responsible for program administration

DEM – Div. of Env. Management
DLR – Div. of Land Resources
DMF – Div. of Marine Fisheries
DPR – Div. of Parks & Recreation

Figure 3.6.1.4.6
Critical Uses/Authorities Matrix
Source: U.S. Department of Commerce; N.C. Department of Natural Resources and Community Development

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.6 Development Controls

3.6.2 Wastewater Facilities Regulations

WASTEWATER TREATMENT REGULATIONS ADMINISTERED BY TWO STATE AGENCIES

> **Currently the North Carolina Division of Environmental Management regulates the construction and operation of wastewater management facilities that consist of a public or community sewage system and any system which discharges to the land surface or surface waters. The Department of Human Resources governs the operation of all privately owned septic tank/soil absorption systems through the county health departments.**

Until recently, jurisdiction over the permitting of septic tank/soil absorption systems was shared between the Division of Environmental Management and the Division of Health Services. Systems with a capacity of 3000 gallons or more were governed by DEM regulations while systems of less than 3000 gallons capacity were under the jurisdiction of the Division of Health Services regulations, administered by the local governments.

Recent revisions to the Ground Absorption Sewage Treatment and Disposal Act transfers jurisdiction over all subsurface disposal systems to the Division of Health Services and local governments. However, limitations formerly imposed by DEM have been incorporated into the new law. Regulations implementing the revised law went into effect July 1, 1982.

DEM has retained jurisdiction over all wastewater treatment systems which discharge to surface lands or waters.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.6 Development Controls

3.6.2 Wastewater Facilities Regulations

3.6.2.1 Septic Tank/Soil Absorption Systems

THE USE OF SEPTIC TANK/SOIL ABSORPTION SYSTEMS ON THE BARRIER ISLANDS IS PRIMARILY REGULATED BY ONE STATE ACT

The Department of Human Resources regulation governs the installation of privately-owned, individual septic tank systems that do not discharge the effluent to the land surface or surface waters.

Permitting the installation of privately-owned septic tank/soil absorption systems is the responsibility of the local county health department under the Department of Human Resources (DHR) regulation (North Carolina Administrative Code Title 10, Chapter 10, Subchapter 10A, Section .1900). In addition, more stringent local regulations may also be adopted.

Although the Department of Human Resources regulation does not include density restrictions, there are design criteria and site restrictions which, in effect, limit development density. These provisions include horizontal distance requirements between septic tank/soil absorption systems and items such as wells, buildings, water lines, etc. However, the requirements primarily affect new development on lands not platted prior to January 11, 1983. The regulation provides for variances of the design criteria and site restrictions on those residential lots specifically described in a recorded deed or plat prior to 1983. Since much of the barrier island lands were platted prior to this date, the effect of this regulation on residential development is limited in many areas.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT
3.6 Development Controls
3.6.2 Wastewater Facilities Regulations
3.6.2.2 Wastewater Treatment Plants

COASTAL WASTEWATER TREATMENT AND DISPOSAL REGULATIONS INDIRECTLY LIMIT DEVELOPMENT DENSITY AND ENCOURAGE CENTRALIZED WASTEWATER COLLECTION AND TREATMENT

Provisions in the coastal waste treatment disposal regulations, as administered by the Division of Environmental Management, indirectly limit development density. These include restrictions on discharges to SA waters and "green area" requirments for subsurface discharges. The regulation states directly that the policy of the Environmental Management Commission is to promote centralized collection and treatment facilities.

Permitting the construction and operation of wastewater collection and treatment facilities is the responsibility of the North Carolina Division of Environmental Management and is subject to all the general regulations of that agency governing procedures for permits and approvals (Subchapter 24, Chapter 2 of Title 15 of the North Carolina Administrative Code). Permitting construction of wastewater treatmetn facilities on the barrier islands, however, is also specifically subject to Section .0400, Subchapter 2H, Chapter 2 of Title 15 of the North Carolina Administrative Code governing coastal waste treatment and disposal.

This regulation includes provisions for public or community sewage systems which discharge to land surface or surface waters. In general, the regulation indirectly limits development. For instance, the regulation prohibits the discharge of wastewaters to SA waters regardless of treatment. Since, with the exception of Currituck Sound and Cape Fear River, nearly all waters on the mainland sides of barrier islands are classified SA, wastewater treatment plants with surface water discharges on barrier islands are rare. A few privately owned package plants as well as the Wrightsville Beach municipal plant, which were constructed prior to the regulation which discharge to SA waters, are still in operation; however, a proliferation of package plants with sound discharges to accommodate barrier island development cannot occur.

Conventional wastewater disposal not requiring discharge to SA waters or large areas of land are generally too costly for use on a small scale. For this reason, larger centralized collection and treatment facilities are needed to make these alternatives economically feasible. In addition to this indirect encouragement, the coastal regulation requires that when centralized collection and treatment facilities are available, package plants and septic tanks must be abandoned. This is in keeping with the statement of policy section of the regulation that states that the policy of the Environmental Management Commission will be to promote area-wide wastewater collection and treatment to the fullest practicable extent.

MOST HISTORICAL SITES ON BARRIER ISLANDS ARE ASSOCIATED WITH MARITIME OPERATIONS

Most of the historic sites located in the study area are associated with the maritime culture of these islands, including numerous lighthouses and several Civil War forts. The U. S. S. Monitor is located offshore southeast of Cape Hatteras. The Wright Brothers National Monument is located at Kitty Hawk. Ancient cultures inhabited the coastal area as early as 10,000 B.C. The earliest tribes hunted game while later Indians utilized the fisheries resources as well. Current knowledge is limited however since many islands have not been thoroughly surveyed.

Historical resources refer to sites that were established by the settlements of European cultures from 1650 to the present time. The Spanish first visited the Cape Fear region in the 1520's, but no permanent settlement was established. In 1584, Sir Walter Raleigh began efforts to explore and colonize the Outer Banks region. The first of these settlements on Roanoke Island was lost due to what appears to have been a hurricane in 1586. The people that lived on the islands survived by fishing, raising livestock and salvaging shipwrecks. Until the late 1700's, the settlements were usually located on the sound side of these islands in the wooded hammocks for protection from storms. Some of these old villages (Hatteras, Ocracoke, and Portsmouth) are still found on the islands. The islands have been utilized by vacationers since the mid-1700's to early 1800's. Most of this development was on the sound side until after the Civil War when building began on the ocean fronts. Earliest reports of such development include Wrightsville Beach, Atlantic Beach and Nags Head Beach.

Not all the settlements in this area have survived to the present. Diamond City at Cape Lookout was abandoned in 1899 because the inhabitants were discouraged by the frequent storms which have always plagued this coastline. Other areas which have succumbed to storms are Rice Path on Bogue Banks and Portsmouth on Portsmouth Island at Ocracoke Inlet.

Sites of historic importance are displayed in the Atlas. The sites included are those currently listed on the National Register of Historic Places, most of which deal with the maritime culture of the area. The offshore region has long presented complex navigation problems for ships. To aid with navigation, a number of lighthouses have been established along this coast. Some of these listed on the National Register include Bald Head Light, Cape Lookout Light, Ocracoke Lighthouse, Cape Hatteras Light and Currituck Banks Light. Also of historic importance are the three Civil War forts, Fort Raleigh on Roakoke Island, Fort Macon on Bogue Banks, and Fort Fisher north of Cape Fear.

Numerous ships have run aground or sunk in storms alogn this coastline; however, most are not considered historic sites. The U. S. S. Monitor, of Civil War fame, sank southeast of Cape Hatteras during a storm and is listed on the National Register of Historic Places. Also of historic note is the Wright Brothers National Monument at Kitty Hawk.

Archeological resources refer to evidence of those cultures which inhabited this region before the European settlement. The earliest knowledge of native American cultures comes from the period between 8,000 to 10,000 B.C. at the close of the Pleistocene Epoch (Phelps 1975). Evidence for this culture comes from distinctively shaped spear points utilized for hunting large animals. Evidence indicates that hunting parties would move from hunting ground to hunting ground. Since sea level rise and island migration have caused significant changes, many of these sites have been lost or are in submerged offshore areas.

The period from 10,000 B.C. to 2,000 B.C. is known archeologically as the Archaic Stage. Coastal inhabitants relied on deer and bear and discovered the usefulness of oysters and other fisheries. Most Archaic sites are located in the higher elevations of the coastal plain and show that the inhabitatnts lived in larger villages. Evidence of the Archaic stage on the barrier islands is limited to the last 1,000 years because the islands as they are today did not exist during this time (Phelps 1975). The time from 2,000 B.C. to 1 A.D. is poorly understood. However, there is evidence of an influx of new tribes from both the north and south. The northern culture (north of Tar-Pamlico basin) brought distinctive cord-marked ceramics and probably introduced the bow and arrow, while the southern cultures introduced new ceramic pottery (Phelps 1975).

The most significant feature between 1 A.D. to 1,000 A.D. was the use of agricultural crops by the Indians in addition to seafood and game (Phelps 1975). The period from 1000 A.D. to 1650 A.D. is the best known period for the coastal region. The Algonkians were a complex society inhabiting an area from the Pamlico River northward. Their culture was based on agriculture and supplemented with hunting and fishing. These tribes utilized the barrier islands as hunting and fishing camps; main villages were usually located on the mainland (Hall 1981). The southern tribes were probably Siouans, and little factual information exists for these tribes (Phelps 1975). All of the Indian cultures were destroyed after the establishment of European settlements in 1650.

Much of the barrier islands region has not been surveyed for the existence of Indian sites. The known archeological sites are displayed in the Atlas, but due to geological and morphological changes on these islands, this listing cannot be considered complete.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.8 Storm Event/Damage History

STORMS CONTINUALLY IMPACT THE NORTH CAROLINA COAST

North Carolina has been affected by both tropical and extratropical storms. These storms have been responsible for extensive damage on the barrier islands. Most of the severe damage results from the storm surge or hurricane tides from these storms. Past damages have been high, but future damages may be more significant due to exdtensive new development since the last great hurricane.

The barrier islands and coastal region of North Carolina have been affected by numerous storms in the past. These storms are represented by both tropical (tropical storms, hurricanes, and great hurricanes) and extratropical (high and low pressure northeasters) storm events. These storms are normal occurrences along the Atlantic and Gulf coasts and have been recorded throughout history.

Section 3.8.1 discusses historic storm events and the areas most likely to be affected by storms. The future storms are of extreme concern because of the continued interest in barrier islands for resort and retirement living. Sections 3.8.2 and 3.8.3 discuss the estimates of past damages to the barrier islands from beach and dune erosion as well as structural damage from storms. Also included are the policies for beach erosion control, flood protection, dune restoration, and flood insurance programs. While past damage estimates have been high, it is acknowledged that with the amount of expansion in coastal areas, damages from the next great storm will be more severe.

COASTAL NORTH CAROLINA AFFECTED BY TROPICAL AND EXTRATROPICAL STORMS

The coastal region of North Carolina has been affected by numerous storm events. These storms include tropical storms and hurricanes, which occur during summer to late fall, and northeasters which occur from winter to spring. In the past, these storms have been responsible for beach and dune erosion, inlet formation and destruction, and heavy damage to buildings and crops.

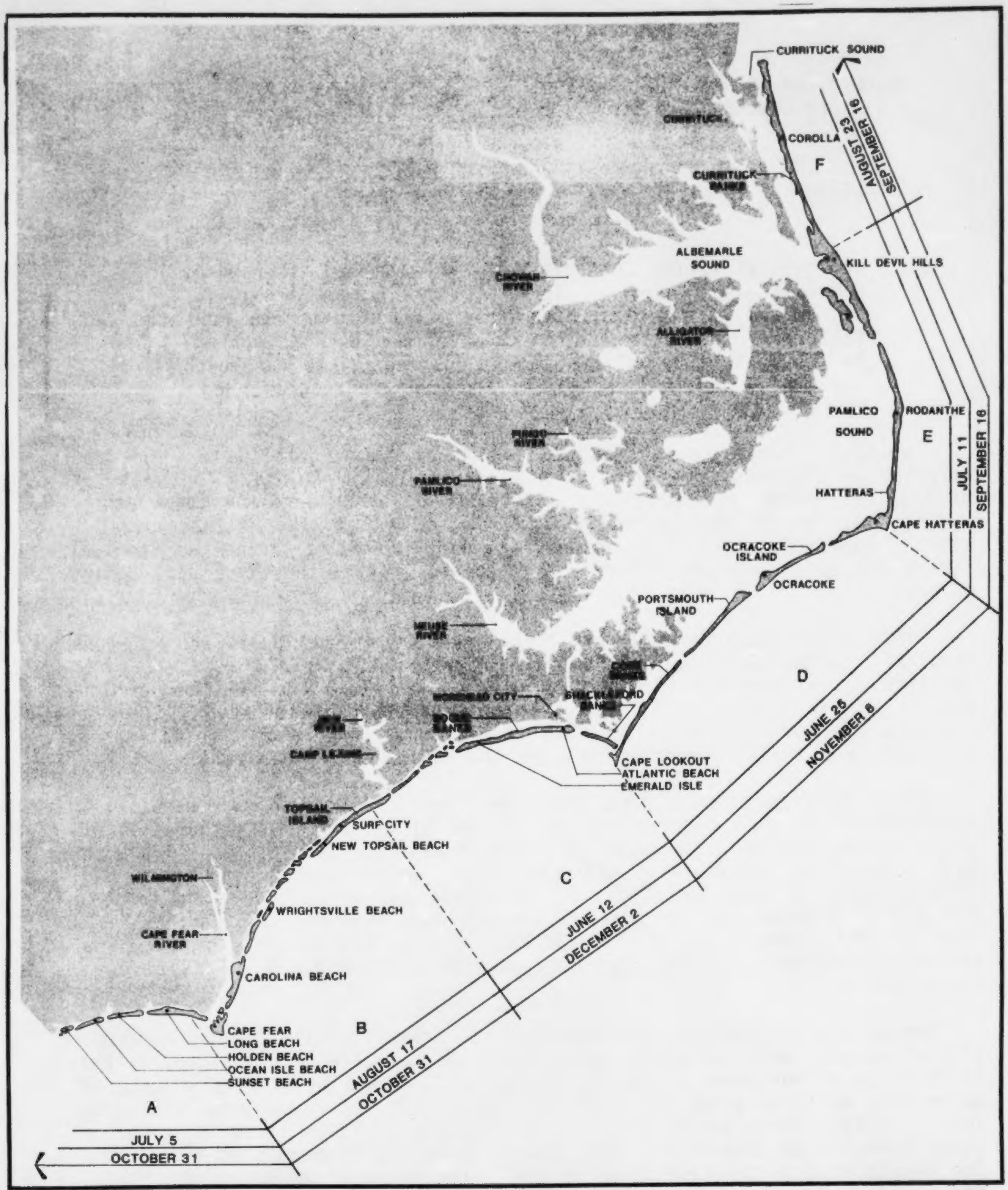
Throughout history, the coastal region of North Carolina has been affected by storms of both tropical and extratropical origin. The majority of tropical storms and hurricanes affecting the North Carolina coast occur during late August through October (Neuman et al. 1977). Extratropical storms, commonly called northeasters, are usually not as intense as tropical storms and hurricanes and occur most frequently during the winter and spring months.

Since 1899, North Carolina has been struck by 21 hurricanes and numerous tropical storms. Considering both the Atlantic and Gulf coasts, North Carolina ranks third behind Florida (50) and Texas (31) for the most tropical storms between 1899 and 1977 (Neuman et al. 1977). Figures 3.8.1.a-d indicate the number, probability, and periods of occurence of tropical storms and hurricanes for different zones along the North Carolina coast.

While most hurricanes pass over the coast in one or two days, northeasters may last several days to a week (Baker 1978). The duration of these storms, not the intensity, is the main cause of destruction. The Outer Banks region is particularly susceptible to these storms because these islands protrude from the mainland. Bosserman and Dolan (1968) identified 857 storms of this type for the area between Nags Head and Cape Hatteras from 1942 to 1967. This study also showed that minimum wave heights of 1.6 m (5.1 ft) were produced every ten days with wave heights of 3.4 m (11 ft) every three months.

Damage due to tropical and extratropical storms results from a combination of waves, rains and winds. The most damaging effects are caused by the storm surge or hurricane tides. Storm surge is caused by massive amounts of water that build up along the coastline, primarily associated with hurricanes (Baker 1978). Storm surges have reached heights of 3.0 m (10.0 ft) or more above normal high tide during past storms (Baker 1978, Neuman et al. 1977). The second most destructive force is the heavy rains which add to the flooding problems in these low-lying areas. The wind is probably the least destructive force; however, high winds add to the storm surge build-up along the shelf and contribute to the destruction of coastal structures and vegetation.

The most severe hurricane to affect the North Carolina coast in recent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SUNSET BEACH
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JULY 5
OCTOBER 31

LEGEND

- — — ——— Sector Boundary
- ←——— Sector Extends Into Adjoining State

Figure 3.8.1.a

Earliest and latest occurrences of tropical storms with maximum sustained winds of 40 miles per hour or higher. Dates indicate landfalls made by storms in each sector for the period 1886-1970 (based on Baker 1978).

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

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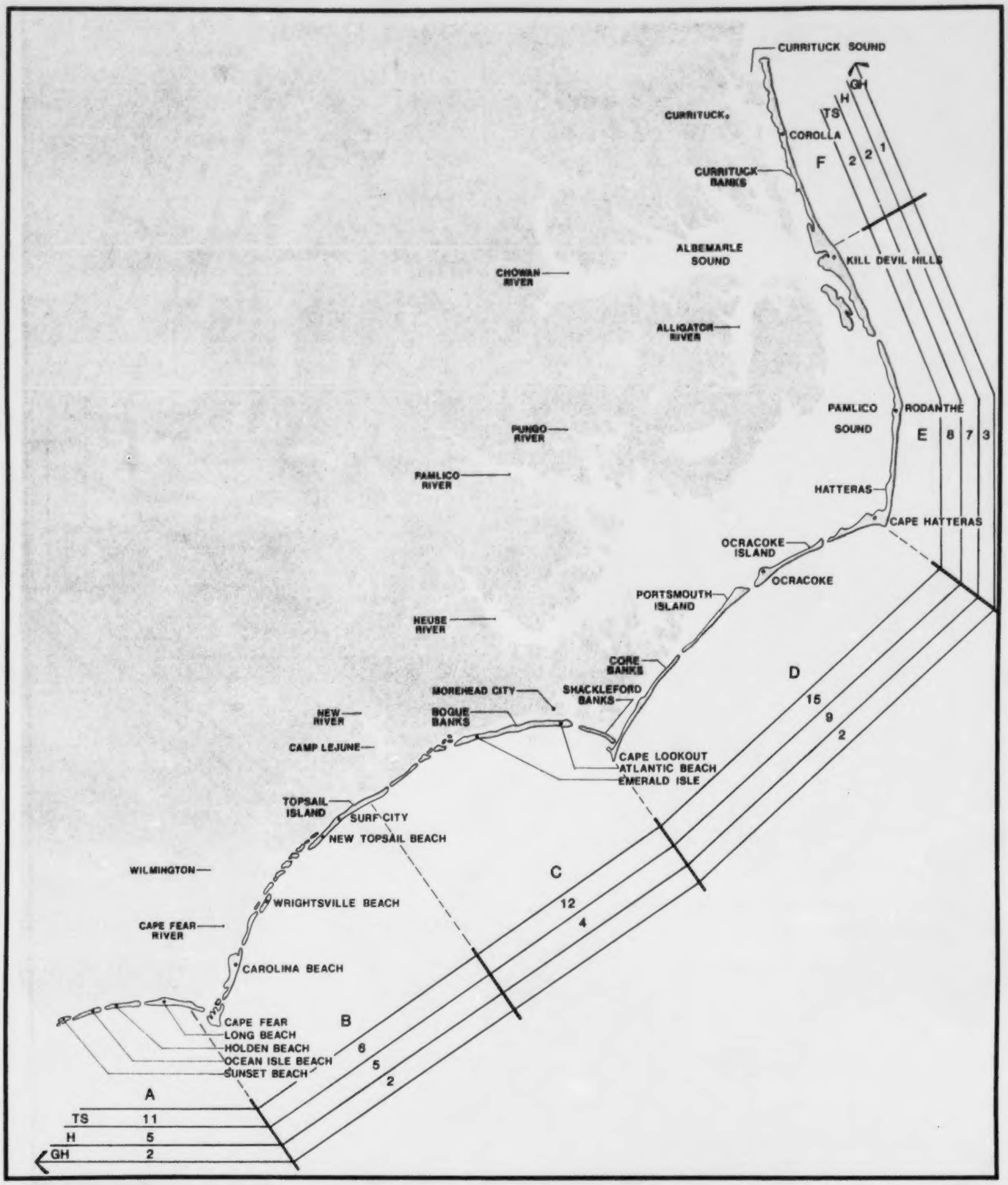
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LEGEND
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TS All Tropical Storms (40 MPH or Higher)
H All Hurricanes (74 MPH or Higher)
GH Great Hurricanes (125 MPH or Higher)

Figure 3.8.1.b

Total number of tropical storms, hurricanes, and great hurricanes reaching the North Carolina coast from 1886-1970 (based on Baker 1978).

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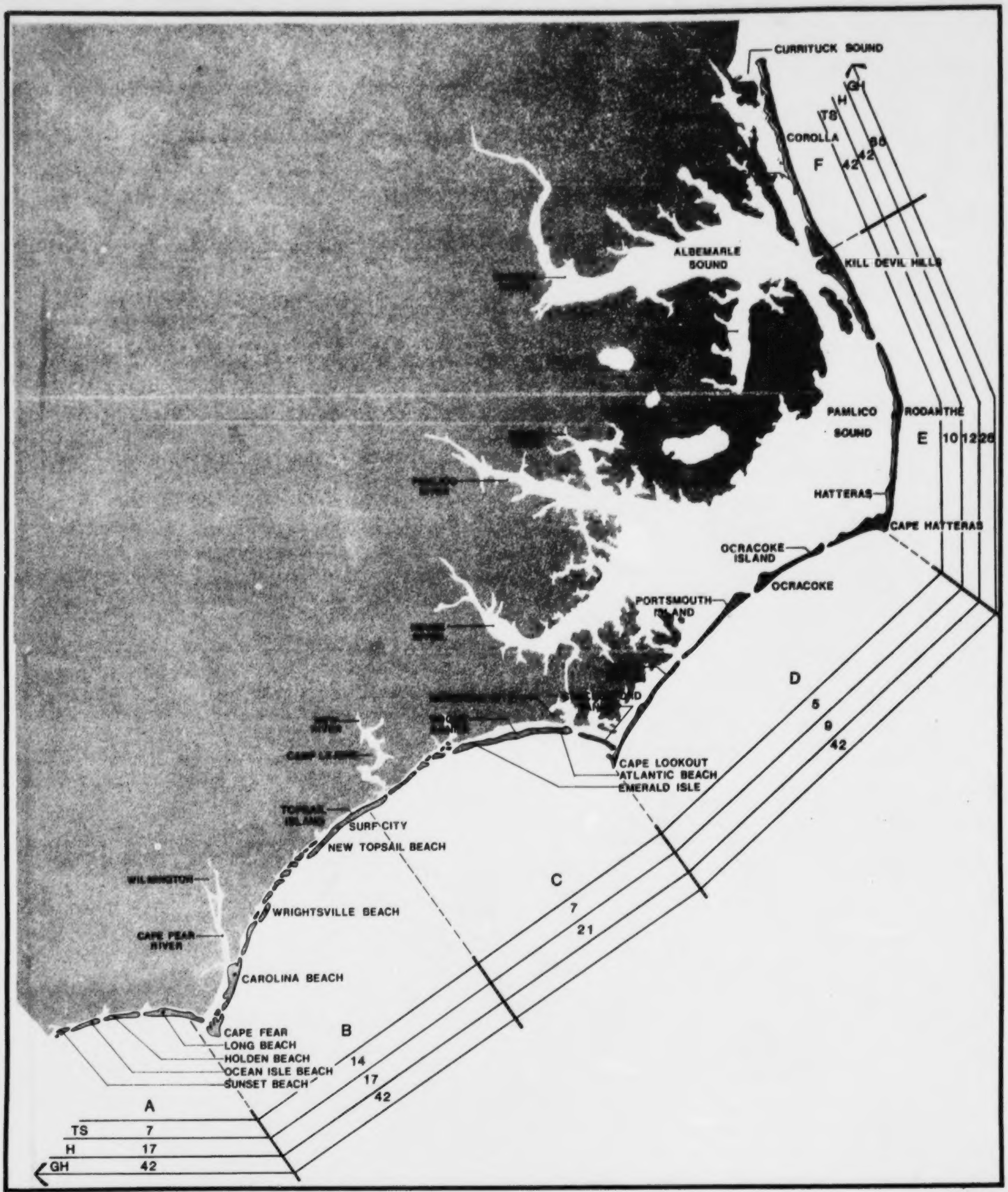
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LEGEND
- - — Sector Boundary
← Sector Extends Into Adjoining State
TS All Tropical Storms (40 MPH or Higher)
H All Hurricanes (74 MPH or Higher)
GH Great Hurricanes (125 MPH or Higher)

Figure 3.A.1.c

Number of years between tropical storm occurrences. Average for the period 1886-1970 by sectors. (based on Baker 1978).

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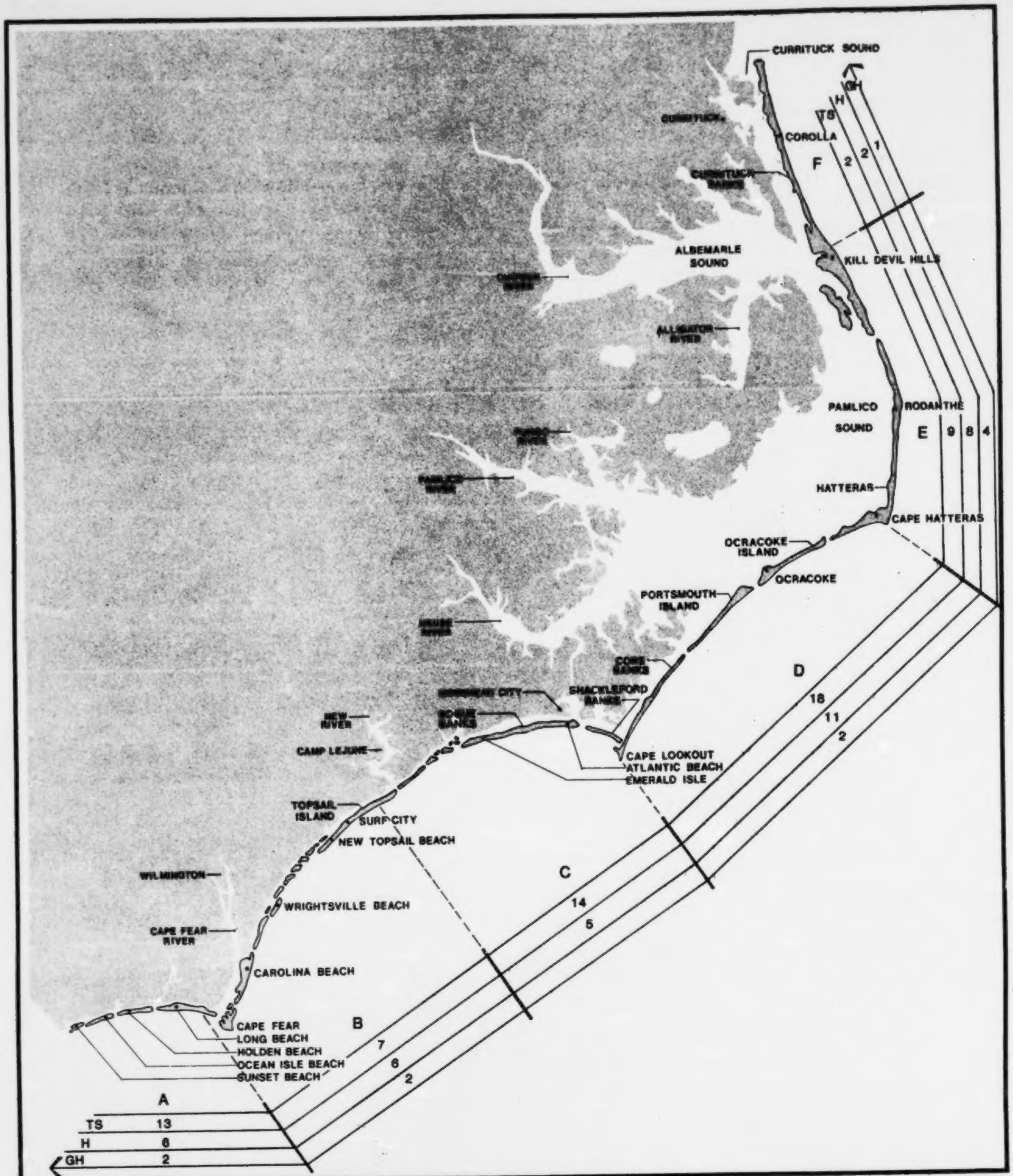
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GH 2

LEGEND
- - — Sector Boundary
← Sector Extends Into Adjoining State
TS All Tropical Storms (40 MPH or Higher)
H All Hurricanes (74 MPH or Higher)
GH Great Hurricanes (125 MPH or Higher)

Figure 3.8.1.d

The probability (percentage) that a tropical storm, hurricane, or great hurricane will occur in any one year in a sector of the coastline.
(based on Baker 1978).

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SCALE IN MILES
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3.8.1 Continued

times was Hazel in October 1954 (rates 4 on the scale of 1 to 5 for severity). The most notable northeaster to strike this coast is known as the Ash Wednesday Storm, which occurred in March 1962. This northeaster had gale to hurricane force winds and offshore storm waves which ranged from 7.6 m (25 ft) along the southern area to 9.2 m (30 ft) above Cape Hatteras (Baker 1978). Section 3.8.2 details storm damage estimates for the Ash Wednesday Storm and several notable hurricanes of the recent past.

PAST DAMAGE ESTIMATES TOP $60 MILLION

Damage estimates provided by the Army Corps of Engineers indicate that major storms during the 1950's and early 1960's caused more than $60 million in damages along the North Carolina barrier islands. Estimates of beach erosion damage, based on the cost of restoration, added another $11.8 million to the total damage estimates. Actual disaster relief expenditures in response to these major storms are unavailable.

During the 1950's and early 1960's, the barrier islands of North Carolina were severely impacted by five major hurricanes and a northeaster. These storms caused structural damages estimated by the Army Corps of Engineers of more than $60 million. Although parallels are difficult to draw between historical damage and potential damage, the magnitude of previous losses illustrates the hazards to coastal development.

The Army Corps of Engineers has also estimated beach erosion damage in terms of restoration costs. Beach replenishment and dune reconstruction are often necessary activities in the wake of a major storm in order to protect remaining development or restroe recreational value. While these costs cannot necessarily be viewed as tangible losses (especially in undeveloped areas), they represent the additional costs of maintaining development on the barrier islands.

Disaster relief in response to a major storm is another type of cost associated with hurricanes. A tabulation of disaster assistance in North Carolina is not readily available since major storm damage has not occurred since 1962 (the Ash Wednesday Storm). However, a discussion of current disaster relief organization is provided in a following section.

3.0 DESCRIPTION OF MANMADE ENVIRONMENT

3.8 Storm Event Damage History

3.8.2 Storm Damage History

3.8.2.1 Structural Damage Estimates

STRUCTURAL DAMAGES TOTALING $31.5 MILLION ILLUSTRATE HAZARDS OF COASTAL DEVELOPMENT

Damage estimates compiled by the U. S. Army corps of Engineers for six major storms between 1954 and 1962 indicate that the barrier islands received approximately 53 percent of all structural damages experienced along the entire North Carolina coast. The barrier islands received a disproportionately high percentage of the total structural damages.

The extent of structural damage caused by major storms is dependent on several factors including the quality of construction, the building location and the severity of the storm. In view of the extensive damage caused by hurricanes in the past, potential damage estimates in anticipation of a major storm are desirable in order to assess the risk involved with coastal development. However, potential damage estimates are virtually impossible to calculate since not all structures can be expected to be destroyed or damaged. In fact, the 1970 Census indicated that nearly 60 percent of all houses in Dare County had been built prior to the Ash Wednesday Storm of 1962, a storm of the intensity to be expected with a 1.0 percent probability in any year.

Recognizing the difficulties with storm damage projections, an analysis of previous storm damage information for the barrier islands of North Carolina was conducted using figures compiled by the Army Corps of Engineers. Following each major storm that affected the coastal area of North Carolina during the 1950's and 1960's, the Army Corps of Engineers conducted damage surveys along the entire North Carolina coast. Compiled according to community and county, this information allows a comparison between damage caused along the Outer Banks and damage caused on the mainland. Structural damage estimates include damage to buildings (public and private), roads utilities and miscellaneous personal property.

According to available statistics, Hurricane Hazel (10/15/54) has been the most severe storm (in terms of property damage) to hit the North Carolina coast during this century. Structural damage estimates totaling $21,150,000 for the barrier island communities amounted to more than 76 percent of the total structural damage caused by this storm in all coastal areas. Damage from Hazel was heaviest in Brunswick and New Hanover Counties, reflecting the extent of barrier island development in these counties as well as the hurricane landfall at the North Carolina/South Carolina state line. Extensive beachfront damage on the barrier islands was caused primarily by storm surge as opposed to winds or rain. had Hazel not hit the coast near the time of high tide, the distribution and cause of major structural damage may have been different.

Damage estimates compiled from five major hurricanes (Hazel, Connie, Diane, Ione and Donna) and the Ash Wednesday Storm of 1962 indicate structural damages totaling $31,478,600 for the barrier islands since 1954. This figure represents more than 53 percent of the total structural damage caused by these six storms along the entire North Carolina coast. These estimates do not include losses caused by the less severe hurricanes and northeasters of the past 30 years. Considering that the barrier islands represent a relatively small percentage of the land area affected by these storms, structural damage on the barrier islands has been disproportionately high. This observation illustrates the increased hazards associated with barrier island development and the need for special considerations concerning building location and construction techniques.

Following the extensive storm activity of the 1950's, the State of North Carolina developed revised building standards for coastal development. These revised standards, along with additional requirements of the National Flood INsurance Program and recent setback requirements of the North Carolina Coastal Area Management Act (CAMA), have greatly improved the quality of construction. However, the difficulty of estimating potential storm damage costs makes it impossible to quantify the benefits (in terms of reduced damage) of improved development.

Table 3.8.2.1 indicates structural damage estimates, by county, for six major storms that have affected the North Carolina coast since 1954.

Table 3.8.2.1. Estimates of Property Damage Due to Storms Along the North Carolina Coast.

County	Hazel 10/15/54	Connie 8/12/55	Diane 8/17/55	Ione 9/19/55	Donna 9/11/60	Ash Wed. 3/5-8/62	Totals
Brunswick	$6,710,000	$ 112,300[1]	$112,300[1]	$112,300[1]	$273,000	-	$7,319,900
New Hanover	9,711,000	1,113,000	433.000	52,000	1,033,100	-	12,342,100
Pender	2,461,000	121,000	48,000	-	725,000	-	3,355,000
Onslow	70,000	-	-	-	-	-	70,000
Carteret	2,198,000	120,000	470,000	131,500	1,812,000	-	4,731,500
Hyde	-	-	-	-	16,000	4,500	20,500
Dare	-	105,500	85,000	97,200	1,123,100	2,228,700	3,639,500
Totals	$21,150,000	$1,571,800	$1,148,300	$393,000	$4,982,200	$2,233,200	$31,478,500
Total Property damage--all coastal areas	27,651,300	3,251,150	2,645,000	4,061,400	9,572,900	12,000,000[2]	59,181,750
Percent damage on barrier islands	76.5	48.3	43.4	9.7	42.0	18.6	53.2

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[1] Damages from all hurricanes in 1955 totaled $337,000 for Brunswick Co. Individual statistics for each storm were not available.

[2] Total damage estimate from Baker 1978.

Source: U. S. Department of Defense, Army Corps of Engineers.

3.0 DESCRIPTION OF MANMADE ENVIRONMENT
3.8 Storm Event Damage History
3.8.2 Storm Damage History
3.8.2.2 Beach Erosion Damage Estimates

BEACH EROSION DAMAGE ESTIMATES TOTALING $11.8 MILLION ILLUSTRATE STORM IMPACT ON THE BARRIER ISLANDS

Following each major storm since 1954, the U.S. Army Corps of Engineers has inventoried damages to the beaches and natural dun systems of the barrier islands. Costs attributed to beach damage are based on the estimated cost of beach and dune restoration. These costs, while not actually representing tangible losses, illustrate the relative severity of the storms and highlight the major points of impact.

Beach erosion and accretion are natural, continuing processes which only become critical where development has occurred. Storms, particularly hurricanes and northeasters, often accelerate erosion in certain locations. While it is difficult to quantify beach erosion as a tangible loss, actual costs are involved when the beach and dunes must be restored in order to protect development and restore recreational assets.

Following each major storm since 1954, the U.S. Army Corps of Engineers has inventoried damages to the beaches and natural dune systems of the barrier islands in North Carolina. Damages are quantified in terms of linear feet and cubic yards of lost dunes and beaches. Costs attributed to beach and dune erosion are based on the estimated cost of restoration. Although these cost estimates may be imprecise, these figures can be used to illustrate the relative severity of the storms, the major points of storm impact, and the additional costs of barrier island development.

Based on available statistics, six major storms between 1954 and 1962 caused an estimated $11,843,200 in beach and dune erosion damage along the barrier islands of North Carolina. The most severe storm (in terms of beach and dune erosion) was the Ash Wednesday Storm of 1962, which caused an estimated $4,250,000 in beach damage in Dare County. Between 1955 and 1962 Dare County has suffered the most damage, with an estimated $6,410,000 in cumulative damages. Actual expenditures for dune construction and beach nourishment are detailed in Section 3.8.3.2.

Table 3.8.2.2 indicates beach erosion damage estimates, by county, for the major storms between 1954 and 1962.

Table 3.8.2.2. Beach Erosion Damage (Estimated Cost of Restoration) Caused by Major Storms, 1954-1962.

County	Hurricane Hazel (10/15/54)	Hurricanes of 1955[1] (Connie, Diane, Ione)	Hurricane Donna (9/11/60)	Ash Wednesday Storm (3/5-8/62)	Totals
Brunswick Co.	$1,000,000	-	$50,000	-	$1,050,000
New Hanover Co.	675,000	$ 300,000	73,200	-	1,048,200
Pender Co.	375,000	350,000	10,000	-	735,000
Onslow Co.	150,000	150,000	-	-	300,000
Carteret Co.	1,000,000	750,000	100,000	-	1,850,000
Hyde Co.	150,000	300,000	-	-	450,000
Dare Co.	-	2,000,000	160,000	4,250,000	6,410,000
TOTALS	$3,350,000	$3,850,000	$393,200	$4,250,000	$11,843,200

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[1] Individual damages for each hurricane were impossible to estimate.

Source: U.S. Dept. of Defense, Army Corps of Engineers.

3.0 DESCRIPTION OF MANMADE ENVIRONMENT
3.8 Storm Event Damage History
3.8.2 Storm Damage History
3.8.2.3 Disaster Assistance

SEVERAL FEDERAL AND STATE AGENCIES PROVIDE DISASTER ASSISTANCE BUT PAST LOSS FIGURES ARE UNAVAILABLE

Because the last major hurricane to affect the North Carolina coast occurred over 20 years ago, figures on federal and state disaster assistance to the barrier islands are not readily available. In addition, a reorganiation of federal disaster response now provides new channels of relief. Several federal agencies provide disaster assistance through the Federal Emergency Management Agency.

The coast of North Carolina has not suffered extensive hurricane damage since the early 1960s. Federal disaster assistance figures for these earlier storms are not readily available at this time. In addition, new agencies and programs are available today that were unavailable several years ago. Therefore, the most appropriate discussion of federal disaster assistance should be concerned with the existing mechanisms for disaster response as opposed to a historical viewpoint.

The Federal Emergency Management Agency (FEMA) was created in 1978 as a result of a reorganization of the federal response to designated national emergencies. FEMA, which draws its basic authority from the Disaster Relief Act of 1974, replaced the former Federal Disaster Assistance Administration. In the event of a declared national emergency, FEMA acts as the coordinating agency for all federal disaster assistance. FEMA also provides direct grants to communities, individuals, and public service organizations to assist with debris removal, repair of vital community facilities and continuation of public services. Additional disaster assistance can be provided by a variety of federal agencies as outlined below:

- Federal Insurance Administration (FIA). FIA provides assistance in the form of insurance claims to individuals participating in the National Flood Insurance Program (see Section 3.8.3.1). A flood does not have to be declared a national emergency in order for the individual to receive payment.

- Small Business Administration (SBA). Provisions of the Disaster Relief Act of 1970 authorize the SBA to provide direct loans or guaranteed/insured loans to businesses or individuals suffering damage as a result of certain designated national disasters.

- Farmer's Home Administration (FmHA). The Farmer's Home Administration is authorized to provide emergency loans to cover losses resulting from designated disasters and to permit continued operations with credit from other sources. FmHA loans are usually issued in response to agricultural damage and may not be applicable to the barrier islands in North Carolina.

3.8.2.3 Continued

- Department of Housing and Urban Development (HUD). The Community Development Block Grant Program (CDBG) can be used to repair or replace vital community facilities damaged by disasters. The Federal Housing Administration (FHA) also provides mortgages or loans for replacement of dwellings extensively damaged by major disasters.

- U.S. Army Corps of Engineers. The Corps may be authorized to provide emergency assistance to protect threatened facilities or restore certain features in the wake of a major disaster.

- Department of Transportation (DOT). The Department of Transportation may, in the event of a major disaster, authorize the expenditure of funds to repair roads, bridges or other transportation facilities that have been damaged.

- North Carolina Department of Crime Control and Public Safety, Division of Emergency Management. The Division of Emergency Management serves a function on the state level similar to that served by FEMA on the federal level. The response to various state departments to major disasters is coordinated through the Division of Emergency Management, which in turn, coordinates activities with FEMA (in the case of a declared emergency). In this way, state and federal disaster assistance is provided in the most efficient and timely manner without duplication of effort.

3.0 DESCRIPTION OF MANMADE ENVIRONMENT
3.8 Storm Event Damage History
3.8.3 Storm and Flood Protection

BEACH EROSION CONTROL REQUIRES CONTINUED MAINTENANCE; NATIONAL FLOOD INSURANCE MAY PROVIDE LONG-RANGE BENEFITS

In the past, erosion control and dune stabilization projects have been viewed as cost-effective methods of offering protection from floods and hurricanes. However, these projects have often proved to be temporary and required continued maintenance. The National Flood Insurance Program, by offering incentives for land use planning and improved construction, may provide the best long-term protection from natural disasters.

As development of the barrier islands has increased, protection has been sought from the hurricanes and northeasters that periodically strike the coast. The initial response from local and federal interests was to construct artificial dunes and renourish eroded beaches. Both the National Park Service and the U.S. Army Corps of Engineers have spent large sums of money on various projects designed to protect established developments. However, as understanding of the natural erosion processes increased along with the costs associated with project maintenance, the National Park Service reevaluated its erosion control policy and eventually abandoned all erosion control activities. Lack of local interest or cooperation also leads to the deauthorization of several Corps projects in 1977. Recent Corps erosion control activities have been confined to Wrightsville Beach and Carolina Beach.

The National Flood Insurance Program offers incentives in the form of subsidized flood insurance to homeowners and communities that adopt recommended guidelines concerning floodplain development. These guidelines, based on detailed floodplain maps and rates, generally control the location of development and construction techniques. The long-term benefits of this program maybe great as new structures are developed with proper consideration of the potential hazards.

3.0 DESCRIPTION OF MAN-MADE ENVIRONMENT

3.8 Storm Event Damage History

3.8.3 Storm and Flood Protection

3.8.3.1 National Flood Insurance Program

PARTICIPATION IN THE NATIONAL FLOOD INSURANCE PROGRAM ON NORTH CAROLINA BARRIER ISLANDS HAS INCREASED MORE THAN 38 PERCENT IN THREE YEARS

Statistics provided by the Federal Emergency Management Agency (FEMA) indicate that the total number of flood insurance policies for structures in barrier island communities in North Carolina increased from 6,659 in January 1978 to 9,239 as of September 1980. The resulting federal subsidy approaches $1.2 million annually. While this change can be viewed as an increase in potential liability, increasing participation in the National Flood Insurance Program also leads to improved land-use planning and construction techniques in barrier island communitites.

The National Flood Insurance Program was created in order to encourage proper land use planning and management of flood-hazard zones, to promote improved construction techniques in the flood plain and to compensate property owners in high flood risk areas. Under provisions of the National Flood Insurance Act of 1968 (PL90-448), as amended by the Flood Disaster Protection Act of 1973 (PL 92-234), homeowners must meet certain conditions in order to be eligible to purchase flood insurance. Flood insurance is required in order to receive any form of federal disaster assistance or federal home mortgage insurance.

The initiative for qualifying for the program rests with the community, which must adopt preliminary land use measures and apply to FEMA for eligibility. Initially, the community participates under the Emergency Program until FEMA issues a Flood Hazard Boundary Map that delineates floodprone areas and conducts a rate study. Ultimately, FEMA provides the community with a Flood Insurance Rate Map and 100-year flood elevation data. Subsidized insurance is then available under the Regular Program for all existing and new construction, except for those buildings constructed in the flood-hazard area after publication of the Flood Insurance Rate Map. Eligibility requirements and individual insurance rates vary according to type of structure, probability of flood and the building location.

According to information provided by FEMA, participation in the National Flood Insurance Program along the barrier islands in North Carolina increased by 38.7 percent between January 1978 and September 1980. As of September 30, 1980, 9,239 policies were in effect for 17 barrier island communities in North Carolina, with a total insured amount of $476,620,000 and a total annual premium of $646,427. Table 3.8.3.1 summarizes these totals on a county and community basis. Based on the total number of policies, the average insured amount on the barrier islands is $51,587 with an average annual premium of $69.96.

Table 3.8.3.1. National Flood Insurance Program Participation in North Carolina, 1/78-9/80.

	As of 1/31/78			As of 10/31/79			As of 9/30/80		
	Total Policies	Total Amount of Insurance	Written Premium	Total Policies	Total Amount of Insurance	Written Premium	Total Policies	Total Amount of Insurance	Written Premium
Brunswick Co.									
Caswell Beach	19	$ 544,600	1,442	35	1,185,100	3,148	47	1,573,300	4,151
Holden Beach	490	16,465,600	31,039	599	24,758,600	39,807	617	28,007,000	43,352
Long Beach	605	19,496,500	44,618	722	27,582,800	55,511	775	32,612,900	60,164
Ocean Isle Beach	470	17,316,800	24,567	591	28,365,700	32,443	643	33,223,600	36,018
Sunset Beach	228	9,091,800	11,358	283	13,672,000	12,734	302	16,217,200	14,743
Yaupon Beach	36	1,301,400	3,247	59	2,721,500	4,415	70	3,369,600	4,907
Sub-Total	1,848	$64,216,700	$116,271	2,289	$98,285,700	$148,058	2,454	$115,003,600	$163,335
Carteret Co.									
Atlantic Beach	429	13,954,000	39,058	459	19,560,400	37,682	550	27,762,100	42,839
Emerald Isle	369	13,541,800	24,256	543	28,034,500	21,825	603	35,193,100	24,300
Pine Knoll Shores	184	5,740,900	16,902	341	14,204,000	33,227	455	39,397,200	15,284
Sub-Total	982	$33,236,700	$80,216	1,343	$61,798,900	$92,734	1,608	$102,352,400	$82,423
Dare Co.									
Kill Devil Hills	768	29,358,600	36,339	1,057	48,936,000	50,160	1,182	57,915,300	55,019
Manteo	51	1,734,700	3,758	65	2,495,200	4,929	71	3,243,900	5,067
Nags Head	926	40,247,300	56,871	1,203	61,952,900	68,634	1,279	72,246,200	75,505
Sub-Total	1,745	$71,340,600	$96,968	2,325	$113,384,100	$123,723	2,532	$133,405,400	$135,591
New Hanover Co.									
Carolina Beach	449	11,670,400	30,402	573	18,379,800	43,088	622	22,892,900	49,722
Kure Beach	66	1,783,900	5,429	93	3,106,300	9,432	107	3,529,200	10,765
Wrightsville Beach	849	35,187,700	80,275	1,047	57,792,700	111,286	1,073	63,269,300	119,162
Sub-Total	1,364	48,642,000	116,106	1,713	$79,278,800	$163,806	1,802	$89,691,400	$179,649
Pender Co.									
Surf City	284	7,733,000	21,874	310	11,205,100	26,294	328	13,033,600	28,785
Topsail Beach	436	14,239,900	40,748	520	21,023,600	53,664	515	23,133,600	56,644
Sub-Total	720	$21,972,900	$62,622	830	$32,228,700	$79,958	843	$36,167,200	$85,429
Grand Total	6,659	$239,408,900	$472,183	8,500	$384,976,200	$608,279	9,239	$476,620,000	$646,427

Source: National Flood Insurance Program: Report AVARGSM2
Report dates: 1/31/78, 10/31/79 and 9/30/80.

3.8.3.1 Continued

According to FEMA (as of May 1980), the average annual cost to the federal government per policy, based on national statistics from the past ten years, has been $200.94 ($166.00 in loss payments, $16.17 for commissions, and $18.77 for servicing). In the North Carolina barrier island communities this represents an average annual subsidy of $130.98 per policy. Based on the total number of policies (9,239 as of 9/30/80) and the average annual subsidy ($130.98 per policy), the total annual subsidy to North Carolina barrier island communities is approximately $1,210,124 for flood insurance. These figures are based on national statistics, not actual losses in North Carolina communities.

Another estimate of flood insurance subsidy on the barrier islands can be derived by looking at insurance costs associated with homes in the V zone. The V zone is defined as an area subject to high velocity waters, including hurricane wave wash. Most homes on the barrier islands would likely be considered in the V zone. (A detailed study to delineate V zones in North Carolina is currently under way). According to statistics from the Federal Insurance Administration for the period 1/1/78 to 4/23/80, the average operating deficit for homes located in the V zone was $282.46 per policy. This represents an approximate annual deficit of $122.00 per policy. Based on the total number of policies (9,239 as of 9/30/80) and the average annual deficit ($122.00 per policy), the total annual deficit (subsidy) to North Carolina barrier island communities is approximately $1,127,158 for flood insurance. This figure corresponds with the previously derived estimate based on overall national statistics.

It may be argued that the federal subsidy for flood insurance promotes development in hazardous areas and primarily benefits private homeowners. The fact remains that communities must adopt and enforce certain land use and stormwater management ordinances and construction standards in order to qualify for the program. In the long run, the National Flood Insurance Program may be less costly than continued disaster relief resulting from improper land management and inadequate construction.

3.0 DESCRIPTION OF MANMADE ENVIRONMENT

3.8 Storm Event Damage History

3.8.3 Storm and Flood Protection

3.8.3.2 Beach Erosion Control

SINCE THE 1940's MORE THAN $29 MILLION HAS BEEN SPENT FOR EROSION CONTROL ON NORTH CAROLINA BARRIER BEACHES

Various dune restoration and beach renourishment projects have been undertaken in order to counteract natural erosion and protect endangered communities along the North Carolina coast. The lead agencies in most of these projects have been the National Park Service and the U.S. Army Corps of Engineers. Since 1940, more than $29 million has been required to construct and maintain these projects.

Erosion protection and prevention measures have been used along the barrier islands of North Carolina for many years. Individual sand dikes and fences were likely constructed throughout the history of settlement on the islands. Prior to 1940, one of the initial organized storm protection efforts was carried out by the Civilian Conservation Corps, which constructed sand fences along various sections of the Outer Banks (most notably in the Cape Hatteras area). In 1936 the National Park Service was given responsibility for restoring the Outer Banks and undertook a series of dune stabilization efforts. After the hurricanes of 1954 and 1955, the Federal Civil Defense Administration financed emergency measures to restore eroded dunes and strengthen various segments of the ocean shoreline.

Between 1952 and 1973, the National Park Service continued dune restoration and erosion control activities in order to protect the beaches and the private settlements remaining on Hatteras Island. Throughout the 1960's, beach erosion control was a regular part of the NPS budget with annual appropriations of $500,000. Larger appropriations were often made in response to major storms. Following the Ash Wednesday Storm of 1962, the NPS spent approximately $1,360,000 for dyke construction and dune stabilization. In 1971, $4.3 million was appropriated for beach restoration in response to Hurricane Ginger. This appropriation permitted the NPS to undertake its largest beach renourishment project at Buxton, just north of the Cape Hatteras lighthouse. After considerable debate in the early and mid-70's, the NPS reevaluated its erosion control policy and announced a general policy of no beach stabilization for any part of the federally-owned shoreline. Inlet management, protection of cultural resources (lighthouse and transportation links) would be dealt with on a case-to-case basis. Up to that time, the NPS had spent approximately $20 million for dune stabilization and erosion control.

The U.S. Army Corps of Engineers, with authorization under the Flood Control Act of 1966 and the Rivers and Harbor Act of 1966, has also undertaken several erosion control/hurricane protection projects along the barrier beaches of North Carolina. Projects are usually undertaken in response to local or state initiatives. To date, beach renourishment and dune stabilization projects have been undertaken along Carolina Beach

3.8.3.2 Continued

($3,189,000), Wrightsville Beach ($6,058,221) and at Fort Macon State Park ($620,000). Approximately $455,606 was spent on a project for Brunswick County beaches before the project was classified as inactive due to a lack of local interest. The federal government also contributes towards the annual maintenance cost of these projects for ten years following project completion.

The total cost for the Wrightsville Beach project includes beach renourishment undertaken within the last year at a cost of approximately $5 million. The Fort Macon State Park project has work yet to be completed. Additional projects have been proposed along Bodie Island, Topsail Beach/Surf City and Cape Lookout but have not been implemented due to a lack of local interest or cooperation. The only new project planned by the ACOE involves additional beach renourishment at Carolina Beach. The estimated cost of this proposed project is approximately $10-$12 million, of which approximately $3.5 million is the state/local share of the money. This project is expected to be implemented. Of the total $9,767,221 that has been expended on ACOE projects, approximately $2,778,000 was from local sources.

Beach erosion control projects often have multiple benefits which justify their cost and anticipated maintenance. According to the ACOE (1979), benefits for the projects at Carolina Beach, Wrightsville Beach and Fort Macon State Park total approximately $3,550,300 annually. These benefits are quantified in terms of damages prevented, flood control, recreation and area redevelopment.

Considering the projects undertaken by the NPS and the ACOE, approximately $29, 867,000 has been spent for erosion control and related projects along the barrier beaches of North Carolina. This total does not include additional projects such as groin and seawall construction undertaken by state or local interests.

Generally, beach renourishment and erosion control projects are designed as continuing activities which require annual maintenance. The reversal of NPS policy in 1973 and the dwindling interest in ACOE projects may signify the end to these types of projects in North Carolina. However, in certain areas where the expense of beach renourishment can be justified in terms of continued economic development and tourism (such as Wrightsville Beach and Carolina Beach), local interests will probably continue beach renourishment programs.

STATEWIDE 208 PLAN RECOMMENDS CONSIDERATION OF ALTERNATIVES TO REGIONAL WASTEWATER MANAGEMENT FACILITIES

The statewide 208 Plan considers eight different elements of water quality management planning. Some of these are directly related to barrier island 201 planning. Others are more closely associated with inland activities, such as construction, agriculture, mining and forestry. These may have a greater impact on estuarine water resources than barrier island 201 planning. The most important 208 Plan recommendation is that alternatives to centralized wastewater facilities be considered as part of 201 planning funded after October 1, 1978. Since Step 1 monies for pending barrier island 201 Plans were provided before that date, evaluations of specific alternatives to centralized facilities were not included.

The 208 Plan prepared by the North Carolina DNRCD Division of Environmental Management includes eight major elements of water quality management planning. Listed in decreasing order of overall contribution to North Carolina water quality problems (as determined by the 208 Plan), they are as follows:

- Point sources
- Urban stormwater runoff
- Agriculture
- Construction
- Mining
- On-site wastewater disposal
- Solid waste disposal
- Forestry

The Water Quality Management Plan is concerned primarily with non-point sources of pollution, although one section of the plan deals specifically with point sources. The 201 Facilities Plans are site specific and deal primarily with point source water quality management planning. Various elements of 208 planning are related to 201 facilities planning for barrier islands, including point sources, urban stormwater runoff, on-site disposal and, to a lesser extent, construction and solid waste disposal.

Other elements of 208 planning such as agriculture, mining, and forestry are primarily associated with inland activities which generate nonpoint source pollution. The impact of these activities on estuarine water quality, however, may be significantly greater than any activities related to barrier islands. The removal of forests and draining of large tracts of land for large-scale farming operations decreases salinities and increases sediment and nutrient concentrations in the sounds. Phosphorus mining activities in northeastern North Carolina may also contribute to excess nutrients in the Pamlico Sound. Peat mining may also decrease salinities. Inland construction generates additional sediments and creates impervious areas resulting in increased freshwater runoff. Impacts of 201 planning on overall estuarine water quality and marine resources may be minimal compared to the effects of inland activities.

3.9 Continued

Point sources, urban runoff, on-site wastewater disposal, construction and solid waste disposal are considered to affect 201 facilities planning on the barrier islands. The 208 Plan contains specific recommendations that should be considered in barrier islands planning. These recommendations, as well as a discussion of 201 plan compatibility with each recommendation, are summarized below.

Urban Stormwater Runoff

208 Recommendation

The Division of Environmental Management should continue some low cost, non-intensive educational efforts (such as speaker's bureau, slide show, occasional feature articles, cooperation with a newsletter) in urban areas of the state to increase awareness of urban pollution sources and potential remedies. Street cleaning, catch basin cleaning, and covering of industrial chemical stockpiles are maintenance activities that would require modest expenditures and are administratively simple. Detention basins, infiltration strips and depressed areas for detention in parking lots are low cost structural methods which can be used to reduce the velocity and concentration of pollutants of stormwater.

201 Compatibility

The issue of non-point source pollution is not addressed in the 201 facilities plans for the barrier islands. Because installation of municipal sewerage systems will make possible higher density development, urban runoff may become an increasingly important source of water pollution on barrier islands if the proposed alternatives are implemented.

In order for the 201 Plans to be more compatible with the intent of the 208 Plan recommendations, the 201 Plans should identify potential water quality problems associated with runoff from high density development as well as mitigative measures that can be taken to reduce the impacts of stormwater runoff.

On-Site Wastewater Disposal/Point Sources

208 Recommendation

1. The Division of Environmental Management will assure that 201 Plans funded after October 1, 1978, include an analysis of alternative noncentralized wastewater treatment systems for communities within the planning area experiencing documented wastewater disposal problems. Agencies in areas with approved facility plans will be encouraged to analyze alternatives for documented problem areas for which the approved facility plan proposes no solution.

201 Compatibility

The Step 1 efforts for the six pending 201 Facilities Plans were funded prior to October 1, 1978 and, therefore, would not be required to include an analysis of alternative noncentralized wastewater treatment facilities according to this recommendation. It is evident that the intent of the recommendation, however, is that the possibility of using noncentralized wastewater treatment systems be more adequately addressed.

208 Recommendation

2. The Division of Environmental Management should actively encourage, through the facility grants program, the provision of septage-handling facilities at publicly-owned wastewater treatment plants. Further, it will be a policy of the Division that at each facility planning conference the applicants will be made aware of the grant eligibility of septage treatment facilities. For all municipal facilities planning projects receiving funding after October 1, 1978, including Step 1 grant increases, a determination of the need for septage treatment will be made.

201 Compatibility

Disposal of septage is not addressed in the barrier island 201 Facilities Plans, probably because the plans recommend centralized sewerage systems. However, in each of the planning areas, some sections will continue to be served by on-site disposal systems. The possibility of including facilities for treating septage at the proposed wastewater treatment plants should be considered. Also, any evaluation of using alternative noncentralized instead of centralized sewerage facilities should address the issue of septage disposal.

208 Recommendation

3. The Division of Health Services should report by January 1, 1981 on the status of septage disposal practices in the state. This report should detail areas in which septage disposal is a severe problem and should include information from local health departments and septage handling contractors.

201 Compatibility

The issue of septage disposal is not addressed in the barrier islands 201 plans.

Construction

Although the 208 Plan does not contain specific recommendations with respect to construction or solid waste disposal that relate directly to barrier island 201 facilities planning, the issues should be addressed. Construction of wastewater collection, conveyance, and treatment facilities could cause erosion and sedimentation if adequate control measures are not used. The 201 Plans acknowledge these potential problems as environmental impacts and recommend use of best construction practices to control erosion. The recognition of construction related water quality problems in 201 planning is in keeping with the intent of 208 planning and should help insure that mitigative measures are planned in facilities design and implemented during construction.

Solid Waste Disposal

The disposal of sludge from municipal wastewater treatment works is a major solid waste disposal problem. The recommended method of disposal in the 201 Plans is dewatering and burial in an approved sanitary landfill. Some 201 Plans identify specific landfills while others do not. As evidenced in the 208 Plan, criteria for landfill site suitability are becoming increasingly stringent in an effort to prevent water quality problems associated with leachate. Highly permeable soils in coastal areas may have severe limitations for supporting sanitary landfills. The 201 Facilities Plans should

3.9 Continued

include more detailed information concerning the availability of sanitary landfill sludge disposal sites for the duration of the planning period and include alternative methods of sludge disposal.

4.0 FEDERAL PROGRAMS, PROJECTS AND AGENCIES

FEDERAL AGENCIES SIGNIFICANTLY AFFECT NORTH CAROLINA'S BARRIER ISLANDS

Various federal agencies are involved in the protection, development and alteration of barrier islands. In North Carolina, federal involvement is evident along the entire coast, involving both land and water resources.

North Carolina's barrier islands have been significantly influenced by the involvement of federal agencies. Approximately 23,490 ha (58,300 ac) and 209.3 km (130 mi) of oceanfront are currently protected by the Department of Interior with an additional 6,400 ha (15,800 ac) proposed as a wildlife refuge. Several other federal agencies have contributed more than $44.0 million in the form of low-interest loans and grants to provide community facilities and promote development of the barrier islands. The U.S. Army Corps of Engineers has spent approximately $9.3 million to improve and maintain navigation channels and harbor facilities in the barrier islands.

The following sections detail the federal involvement on the barrier islands of North Carolina.

4.0 FEDERAL PROGRAMS, PROJECTS AND AGENCIES

4.1 Protection of Barrier Islands

THE U.S. DEPARTMENT OF INTERIOR PROTECTS SEVERAL BARRIER ISLANDS

The National Park Service and the Fish and Wildlife Service are actively involved in the protection of several barrier islands in North Carolina. Approximately 23,490 ha (58,300 ac) are currently protected. An additional 6,400 ha (15,800 ac) of barrier island preserve are proposed.

The federal government, through the U.S. Department of Interior, is actively involved in the management and protection of several barrier islands along the North Carolina coast. These management areas include the Cape Hatteras National Seashore, the Cape Lookout National Seashore and the Pea Island National Wildlife Refuge. Another National Wildlife Refuge is proposed in Currituck County near the Virginia/North Carolina state line.

The Cape Hatteras National Seashore, administered by the National Park Service, was authorized by Congress in 1937 and occupies 12,150 ha (30,000 ac) along a 121 km (75 mi) stretch of the Outer Banks. The seashore consists of the southernmost part of Bodie Island and most of Pea, Hatteras and Ocracoke Islands. Eight small enclave communities located on these islands are not part of the National Seashore. The seashore is managed for recreation purposes, and access is available from the mainland via the Roanoke Sound bridge and causeway to Bodie Island and by ferry service to Ocracoke Island.

The Cape Lookout National Seashore, also administered by the National Park Service, was authorized by Congress in 1966 and occupies approximately 11,462 ha (28,300 ac) along a 88.6 km (55 mi) stretch of barrier islands in Carteret County. The Seashore consists of Core Banks, Portsmouth Island and Shackleford Banks. In constrast to Cape Hatteras, Cape Lookout National Seashore is essentially undeveloped with no paved roads and few manmade structures. The Seashore is managed for the general purposes of public outdoor recreation including conservation of natural features. Access to the Cape Lookout National Seashore is limited to private ferries operated under National Park Service permits.

The Pea Island National Wildlife Refuge (NWR), established in 1938, is administered by the Fish and Wildlife Service on the Cape Hatteras National Seashore. This wildlife refuge is composed of 2,396 ha (5,915 ac) of coastal barrier island extending over 19.3 km (12 mi) along North Carolina's Outer Banks from Oregon Inlet southward to the village of Rodanthe. The refuge includes an additional 10,409 ha (25,700 ac) of Pamlico Sound waters on its western boundary. Pea Island is managed to provide habitat and food for migratory waterfowl, loggerhead sea turtles and other species of endangered wildlife.

The Currituck Outer Banks National Wildlife Refuge is proposed to consist of 6,400 ha (15,800 ac) on the barrier islands of Currituck County. This proposed refuge is to be managed in conjunction with the Mackay Island NWR located on nearby Knotts Island and the Back Bay NWR in Virginia. This proposed refuge, if established, will restrict development in this presently natural area.

FEDERAL AGENCIES PROVIDE FINANCIAL AID TO PROMOTE BARRIER ISLAND DEVELOPMENT

Various federal agencies which provide economic development and rural assistance have contributed significantly to the development of North Carolina barrier islands. Grants and loans made to barrier island communities total more than $44.0 million. Loan programs of the Farmer's Home Administration have had the most significant impact.

Development of barrier island communities has been greatly encouraged by a variety of federal agencies. These agencies and their programs are discussed separately below. Table 4.2.a summarizes the federal loan and grant activity that has occurred on the barrier islands of North Carolina.

Farmer's Home Administration

The U.S. Department of Agriculture, Farmer's Home Administration has an active record of providing lending assistance in the form of loans and grants to rural communities. These funds are used to obtain necessary community facilities (water and sewer systems, fire equipment and public buildings), increase business and industrial prosperity, and provide housing opportunities for rural residents in need of assistance. To date FmHA has administered 68 loans and 15 grants in various barrier island communities with a total amount of $34,057,500. Approximately 88 percent of these funds were in the form of low-interest or guaranteed loans. Nearly 58 percent of all funds administered by FmHA have been used for the development of community water systems. Subsidized housing activity of the FmHA on the barrier islands has not been determined; however, this source of assistance has not been widely used. Tables 4.2.b through 4.2.e indicate the type, location and amount of FmHA grants and loans on the barrier islands of North Carolina.

Economic Development Administration

The Economic Development Administration provides a variety of financial assistance in the form of grants and loans to economically distressed areas. Grants of up to 50 percent of the development costs can be used to provide public facilities such as water and sewer systems, access roads to industrial parks or areas, harbor facilities and site improvements for industrial parks. Low-interest loans are also available for public works and development facility projects.

EDA has been moderately active on the barrier islands of North Carolina in Dare, Carteret and Hyde Counties. Since 1969, EDA has obligated $1,213,000 to provide various community facilities on barrier islands. Approximately 75 percent of these funds were grants used for the development of community water-supply facilities.

EDA has also been instrumental in the development of the Wanchese Harbor Project on Roanoke Island. This project, devoted entirely to the seafood processing industry, has cost approximately $7.3 million, of which nearly $4.3 million was contributed by EDA. This project will enhance the economic

Table 4.2.a Federal Loan and Grant Activity on the Barrier Islands of North Carolina.

Agency	Loans	Grants	Total
Farmer's Home Administration	$30,121,300	$3,936,200	$34,057,500
Economic Development Admin.	360,000	5,153,000	5,513,000
Coastal Plains Regional Comm.	-	3,198,500	3,198,500
Small Business Administration	425,000	-	425,000
Rural Electric Administration	854,000	-	854,000
Totals	$31,760,300	$12,287,700	$44,048,000

Source: Area offices of the appropriate federal agency (1980).

Table 4.2.b. Sewer Facilities Financed by the Farmer's Home Administration.

Location	Type	Date	Amount
Carolina Beach	loan	9/22/77	$342,300
Carolina Beach	loan	9/22/77	357,700
Kure Beach	loan	6/11/80	73,000
Manteo	grant	9/9/76	433,000
Manteo	loan	9/9/76	153,500
Manteo	grant	7/25/80	314,600
Manteo (Dare Co.)	loan & grant	-	32,000
Manteo (Dare Co.)	loan & grant	-	40,000
Ocean Isle Beach	loan	5/8/80	337,000*
Ocean Isle Beach	loan	5/8/80	263,000*
Totals:	8 loans		$1,598,500
	2 grants		747,600
			$2,346,100

*Funds committed pending USEPA approval of the 201 Facilities Plan.

Source: Farmer's Home Administration, U.S. Department of Agriculture (1980).

Table 4.2.c. Community Facilities Financed by the Farmer's Home Administration.

Entity	Type	Date	Amount
Avon VFD	loan	5/24/77	$ 50,000
Buxton VFD	loan	10/2/77	50,000
Chicamacomico Banks	loan		97,000
Chicamacomico Banks	loan		103,000
Frisco Fire Prev. Assn.	loan		103,000
Hatteras Fire Prot. Assn.	loan	1/4/79	125,000
Hyde Rural Health (Ocracoke)	loan		66,500
Kill Devil Hills	loan	5/27/80	430,000
Kitty Hawk VFD	loan	7/1/75	140,000
Manteo (Dare Co.)	loan		4,500,000
Manteo (Dare Co.)	loan		1,500,000
Pine Knoll Shores	loan	4/17/79	37,060
Pine Knoll Shores	loan	4/17/79	103,060
Pine Knoll Shores	loan	4/17/79	81,700
Pine Knoll Shores	loan	4/17/79	128,180
Roanoke Island VFD	loan		190,000
Ocean Isle Fire Prot.	loan	7/20/76	50,000
Salvo VFD	loan	5/21/75	30,000
Sunset Beach VFD	loan	1/7/76	76,800
Yaupon Beach VFD	loan	6/25/79	20,000
Totals:	20 loans		$7,829,300

Source: Farmer's Home Administration, U.S. Department of Agriculture (1980).

Table 4.2.d. Business and Industry Development Loans Guaranteed by the Farmer's Home Administration.

Entity	Location	Amount
Nag's Head Realty	Nag's Head	$ 180,000
Harris & Buston	Nag's Head	100,000
Harris & Buxton	Nag's Head	280,000
Manteo Motel	Manteo	235,000
Manteo Motel	Manteo	40,000
Manteo Motel	Manteo	125,000
C.C. Midgett, Jr.	Manteo	500,000
Surf Riders Assoc.	Nag's Head	1,800,000
Croatan Inn	Kill Devil Hills	300,000
Wind & Water, Inc.	Nag's Head	250,000
Wind & Water, Inc.	Nag's Head	15,000
Total:	11 loans	$3,825,000

Source: Farmer's Home Administration, U.S. Department of Agriculture (1980).

Table 4.2.e. Water System Facilities Financed by the Farmer's Home Administration.

Location	Type	Date	Amount
Atlantic Beach	loan	4/23/78	$1,592,000
Atlantic Beach	grant	2/19/80	307,400
Atlantic Beach	loan	2/19/80	8,000
Bogue Banks Sewer & Water	loan	8/29/79	310,000
Bogue Banks Water & Sewer	loan	8/29/79	17,000
Cape Hatteras Water Assn.	loan	12/22/78	227,000
Cape Hatteras Water Assn.	loan	12/22/78	108,000
Cape Hatteras Water Assn.	grant	2/1/69	570,000
Cape Hatteras Water Assn.	loan	2/1/69	705,000
Carolina Beach	loan	9/22/77	400,000
Caswell Beach	grant	8/20/79	17,000
Caswell Beach	loan	8/20/79	97,800
Caswell Beach	grant	8/20/79	15,000
Caswell Beach	loan	8/20/79	12,200
Holden Beach	loan	1/29/79	1,002,000
Holden Beach	grant	1/29/79	218,300
Holden Beach	lloan	1/29/79	98,000
Holden Beach	grant	1/29/79	54,000
Holden Beach	loan	10/27/79	358,000
Kill Devil Hills	loan	5/27/80	875,000
Long Beach	loan	6/5/78	2,190,000
Long Beach	loan	6/5/78	315,000
Long Beach	loan	6/5/78	395,000
Manteo	loan	9/9/76	136,000
Manteo	loan	7/25/80	14,000
Manteo	grant	9/9/76	433,000
Manteo	loan	9/9/76	153,500
Manteo	grant	7/25/80	314,600
Manteo (Dare Co.)	loan	-	500,000
Manteo (Dare Co.)	loan	-	5,500,000
Manteo (Dare Co.)	grant	-	101,000
Manteo (Dare Co.)	grant	-	838,000
Ocracoke Sanitary Dist.	grant	3/27/77	5,600
Ocracoke Sanitary Dist.	loan	3/27/77	160,000
Ocean Isle Beach	loan	1/30/74	300,000
Sunset Beach	loan	1/22/79	480,000
Sunset Beach	grant	1/22/79	231,700
Sunset Beach	loan	1/22/79	20,000
Surf City	loan	10/9/69	325,000
Topsail Beach	loan	9/4/72	400,000
Yaupon Beach	grant	9/5/72	83,000
Yaupon Beach	loan	9/5/72	170,000
Totals	29 loans		$16,868,500
	13 grants		3,188,600
			$20,057,100

Source: U.S. Department of Agriculture Farmer's Home Administration, 1980.

development of Roanoke Island and will indirectly impact the adjacent barrier islands (Bodie and Pea Islands) with the required stabilization of Oregon Inlet.

Recent budget cuts proposed by the Reagan administration have put the future of EDA in question and may eliminate this source of future funds. Table 4.2.f indicates the location and amount of grants made by EDA on the barrier islands of North Carolina.

Coastal Plains Regional Commission

The Coastal Plains Regional Commission (CPRC) was a federally funded agency established in 1966 in response to the Public Works and Economic Development Act of 1965. CPRC was established in order to aid in planning and encouraging the orderly economic development of the coastal plains region. In the past several years, CPRC has funded $3,198,500 for various studies and development projects on the barrier islands of North Carolina. The largest single project involved the expenditure of approximately $2,400,000 for the establishment of three Marine Science Research Centers, two of which are located on barrier islands. Most other funds were spent on various studies on water supply and sewage disposal. Approximately $560,000 has been spent by CPRC for engineering studies associated with the Wanchese Harbor project.

Recent budget cuts requested by the Reagan administration have eliminated the CPRC; therefore, this source of funds will not be available in the future. Table 4.2.g lists the projects funded by the CPRC on the barrier islands of North Carolina.

Rural Electric Administration

The Rural Electric Administration (REA) offers low interest and guaranteed loans to rural electric cooperatives to aid in the expansion of electrical generating, transmission and distribution facilities. The only identified project on the North Carolina barrier islands that has been aided by the REA is the Cape Hatteras Electric Membership Corporation. In June 1978, the REA made a $854,000 loan to this corporation to provide expanded transmission and distribution facilities on Ocracoke Island. These facilities provided electrical service to an additional 420 customers.

Small Business Administration

The Small Business Administration is authorized to grant a variety of loans for several purposes. The SBA draws its basic authority from the Small Business Act of 1953. However, recent provisions of the Disaster Relief Act of 1970 and the Water Pollution Control Act Amendments of 1972 authorize the SBA to provide disaster relief loans to individuals and businesses as well as loans to finance needed waste treatment facilities for businesses. These loan programs could have a significant impact on the barrier island communities in North Carolina.

Since 1962, the SBA has granted 13 loans to individuals in various barrier island communities. The total loan value is $425,000. More detailed information indicating the location of the loan recipients and the type of loans is not available.

Table 4.2.f. Projects Funded by the Economic Development Administration on the Barrier Islands of North Carolina.

Entity	Obligated	Amount
Bogue Banks Water & Sewer (Emerald Isle Water Storage and distribution system)	2/25/69	$ 468,000
Cape Hatteras Water Assn. (Avon, Dare Co. water system expansion)	8/19/75	65,000
Manteo Water Treatment	12/10/68	59,000
(overrun)	6/30/70	23,000
Manteo Sewage Treatment	1/31/69	49,000
(supplement)	6/30/70	14,000
Ocracoke Water System	10/5/73	385,000
(overrun)	6/30/76	150,000
Wanchese Harbor Project	9/20/77	3,000,000
(Roanoke Island)	(overrun)	1,300,000
TOTAL		$5,513,000

Source: Economic Development Administration, Approved Project Directory as of 3/31/78.

Table 4.2.g. Projects Funded by the Coastal Plains Regional Commission on the Barrier Islands of North Carolina.

Project	Date	Amount
Marine Science Research Centers	1971-72	$2,400,000
Wanchese Harbor Project (Engineering Studies)	1976-	560,000
Dare Beaches Water Project	1973	27,000
Ocracoke Water System	1974	55,000
(cost overrun)	1976	76,500
Innovative Sewage Disposal Project (UNC & NC State)	1980	80,000
Total		$3,198,500

Source: North Carolina Department of Intergovernmental Relations (1980).

4.2 Continued

Department of Housing and Urban Development

The Department of Housing and Urban Development (HUD) has the potential to greatly impact barrier island communities. Guaranteed home loans and mortgages through the Federal Housing Administration as well as the variety of subsidized housing programs available to low-income communities could be used to provide increased housing opportunities. Likewise, the Community Development Block Grant (CDBG) Program could be used to provide needed community facilities and promote increased development.

According to the HUD Area Office in North Carolina, the CDBG Program has not been used in any barrier island community in North Carolina and may not be applicable. Similarly, public housing and other assisted housing has not been constructed on the barrier islands. The use of individual FHA insured loans and mortgages has not been determined. Although these various sources of assistance have not yet been used on the barrier islands of North Carolina, these programs are cited here because they represent a significant potential incentive for development.

Federal Emergency Management Agency

Disaster relief funds administered by the Federal Emergency Management Agency serve as an indirect incentive for barrier island development by providing financial aid in the wake of major disasters. The National Flood Insurance Program administered by the Federal Insurance Administration also provides for barrier island development by reducing the risk of loss due to flood. These agencies were discussed in Section 3.8.

U.S. ARMY CORPS OF ENGINEERS PROJECTS IMPACT THE BARRIER ISLANDS

The U.S. Army Corps of Engineers has undertaken a variety of harbor and navigation improvements along the North Carolina coast. These projects impact the natural processes of the barrier islands and indirectly affect the economic development of the coastal area. Mitigation measures reduce adverse environmental impacts.

The U.S. Army Corps of Engineers, Wilmington District, has been moderately active along the North Carolina coast. Projects undertaken by the Corps include harbor and basin improvements, channelization, inlet dredging and stabilization, flood control and beach erosion control. Flood and beach erosion control activities are discussed in Section 3.8.3.2. This section examines the navigation and harbor improvement projects of the ACOE and evaluates their potential impacts.

Federal involvement in navigation improvements stems from the commerce clause of the Constitution and from subsequent decisions of the U.S. Supreme Court. The ACOE is responsible for the construction, as well as the maintenance and operation, of federal river and harbor projects, and the cost is largely federal. Most navigation projects undertaken by the ACOE are authorized under the Rivers and Harbors Act, as amended.

Harbor improvements, channel and inlet dredging and inlet stabilization are all considered navigation improvements. To date, the ACOE has been involved with five harbor projects on barrier islands and 19 channel and inlet projects. Generally, the harbor and basin projects have been in the northern portion of the Outer Banks while the inlet and channel projects have been located along the entire coast. Total cost to date for these projects exceeds $10.5 million. Table 4.3 lists the various navigation projects that have been undertaken along the barrier islands of North Carolina. Not included in this table is the projected cost of $88,100,000 for the stabilization of Oregon Inlet.

Navigation improvement projects impact the barrier islands directly and indirectly. Dredging of channels and inlets and the subsequent disposal of dredge spoil can adversely impact the fragile benthic ecosystem. Inlet stabilization through the construction of jetties can interrupt the littoral drift of sand and significantly alter the natural barrier island processes of erosion and accretion. Harbor and basin improvements can significantly affect the natural marsh communities on the back side of the barrier islands. Additional indirect impacts can result by encouraging increased boat traffic through the inlets and channels and from increased economic development of mainland ports. Harbor improvements at Morehead City, Beaufort and other mainland ports have an undetermined impact on the adjacent barrier islands. Likewise, continued maintenance of the Atlantic Intracoastal Waterway may indirectly impact the neighboring barrier islands.

Table 4.3. Navigation and Harbor Improvements Impacting the Barrier Islands of North Carolina.

Project Basin/Harbor Improvements	Location	Cost
Avon Harbor	Hatteras Island	$ 74,096
Hatteras Basin	Hatteras Island	-
Manteo (Shallowbag) Bay	Roanoke Island	3,141,235
Silver Lake Harbor	Ocracoke Island	184,284
Channel and Inlet Projects		
Atlantic Beach Channels	Carteret Co.	27,046
Barden Inlet	Shackleford Banks	88,328
Bogue Inlet Channel	Onslow Co.	12,615
Drum Inlet	Core Banks	166,119
Lockwood's Folley Inlet	Brunswick Co.	49,749
Morehead City Harbor	Carteret Co.	
Masonboro Inlet	New Hanover Co.	5,614,114*
New Topsail Inlet	Pender Co.	118,503
Ocracoke Inlet	Ocracoke Island	346,240
Oregon Inlet (Manteo (Shallowbag) Bay)		-
Pamlico Sound to Rodanthe	Hatteras Island	42,029
Rollinson Channel	Hatteras Island	589,105
Wallace Channel	Ocracoke Island	132,834
TOTAL		$10,586,297

Notes:* Contract amount awarded in April 1978 for the construction of the south jetty at Masonboro Inlet.

Source: U.S. Army Corps of Engineers 1979.

4.3 Continued

Most inlet and harbor projects along the North Carolina coast provide direct benefits to the seafood industry and local fishermen. According to ACOE estimates commerce along the North Carolina coast waterways increased from an annual average of 2,191,000 tons during the period of 1973-77, to an average of 3,157,000 tons during 1977. Most of this commerce was seafood; however, pulpwood and petroleum contributed to the total tonnage. Harbor improvement projects at Morehead City, Beaufort and Manteo (Shallowbag Bay) have also contributed to the local economies.

The ACOE recognizes the potential adverse impacts associated with navigation projects and has taken steps to mitigate those impacts. Plans for the stabilization of Oregon Inlet include an innovative method of sand bypassing to minimize disruption of the natural erosion processes. In addition, dredge spoil has been used to create artificial islands which serve as habitat and nesting areas for several species of colonial shore birds.

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APPENDICES

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Appendix Table 2.1.1.c Hydrologic Data Sources Available for Specific Coastal Waters.

Area	Type of Study	Numbers Corresponding to Site Specific Sources (Appendix 2.1.1.b)
1. Chowan River Estuary	Hydrological	5, 11
	Water Quality	25
2. Albemarle Sound	Hydrological	8
	Sediments	17
3. Outer Bank Area		
General	Beach erosion	28
	Water resource (Geological Survey)	30
Oregon Inlet and Roanoke Island	Hydrological (includes circulation patterns)	22
Dare Beaches	Ocean outfall	24
Shallowbag Bay	Hydrological	27
4. Cape Hatteras Area	Continental shelf waters characteristics	3, 23
	Shoreline changes (erosional retreat)	7,26
5. Pamlico Sound	Modeling of circulation and hurricane surge	1
	Hydrological studies of Pamlico Estuary	6, 9
	Hydrological	8, 12, 14, 21, 31
	Sediments	18
6. Cape Lookout/Shackleford Banks	Geological (submerged and emerged coastal Plain province)	15
7. Bogue Sound/Newport River Area	Water quality/circulation	2
8. Onslow Bay	Oceanography and fishery	13
	Physical and dynamical experiments	19
9. Cape Fear River	Movement and dispersion of soluble pollutants	10
Northeast Cape Fear River Estuary	Ecological studies (ocean outfall and Dutchman Creek)	4
Lower Cape Fear	Seawater encroachment	29
Fort Fisher	Geological (effect of pre-recent stratigraphic units upon the littoral system)	16
Offshore Area	Geological (submerged shoreline features on the continental shelf)	20

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

Appendix Table 2.1.2.1.a. Water Quality Standards for Tidal Waters of North Carolina.

Parameter	Standard
Phosphorus	<-0.10 ug/l-P
PCB	<0.001 ug/l
Selenium[1]	<0.01 mg/l or 0.01 of the 96-hour LC-50
Hydrogen Sulfide-Undissociated	<2.0 ug/l
Total Dissolved Gases	<110% of Saturation
Turbidity	<25 NTU in receiving water from a discharge
Chlorophyll a	<40 ug/l December-March
	Radioactive Substances
Alpha Emitters[2]	<5 Picocuries/l for average annual maximum combined Radium-226 and 228
	<15 Picocuries/l average annual gross alpha partical activity (including Radium-226 excluding Radon and Uranium).
Beta Emitters[2]	<8 Picocuries/l, average annual maximum for Strontium-90
	<50 Picocuries/l, average annual gross beta particle activity (excluding potassium-40 and other naturally occurring radionuclides)
	<20,000 Picocuries/liter Tritium, maximum average annual activity
	Toxic Substances
Arsenic	<0.1 mg/l
Cadmium	<5.0 ug/l
Chromium	<0.10 mg/l
Cyanide	<5.0 ug/l
Mercury	<0.10 ug/l
Nickel	<0.1 mg/l, or 0.01 of the 96-hour LC-50

Appendix Table 2.1.2.1.a. Continued.

Parameter	Pesticides
Aldrin	≤0.003 ug/l
Chlordane	≤0.004 ug/l
DDT	≤0.001 ug/l
Demeton	≤0.1 ug/l
Dieldrin	≤0.003 ug/l
Endosulfan	≤0.001 ug/l
Guthion	≤0.01 ug/l
Heptachlor	≤0.001 ug/l
Lindane	≤0.004 ug/l
Methoxychlor	≤0.03 ug/l
Mirex	≤0.001 ug/l
Parathion	≤0.04 ug/l
Toxophene	≤0.005 ug/l

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[1] 96-hour LC50 is that concentration at which half the test organisms are killed in a 96-hour period.

[2] Based on at least 4 samples collected quarterly

[3] < Less than the listed concentration
≤ Less than or equal to listed concentration

Source: Environmental Management Commission. 1979. North Carolina Administrative Code Title 15, Department of Natural and Economic Resources, Chapter 2, Subchapter 2B, Section 0.0200.

Appendix Table 2.1.2.1.b. Water Quality Standards for Shellfish Waters (Class SA) of North Carolina.

Parameter	Standard
Floating solids, settleable solids, sludge	Not attributable to sewage, industrial or other wastes
Sewage, industrial wastes Other wastes	Unsuitable for discharge unless meets requirements of the Division of Health Services
pH	$6.8<\mathrm{pH}<8.5$
Dissolved Oxygen	>5.0 mg/l, unless attributable to natural conditions
Toxic wastes, oils, deleterious substances, colored or other wastes	• Only levels above or in combination which will not make waters unsafe or unsuitable for fish and shellfish or their propagation
	• Or impair palatability of the fish or shellfish
	• Or impair waters for other best usage established
Total coliform	• Median less than 70/100 ml MPN, MF
	• not more than 10% of samples shall exceed an MF count or MPN five-table decimal dilution test count of 230/100 ml
	• not more than 10% of samples shall exceed an MPN count of 330/100 ml. Three-tube decimal dilution test
Temperature	• Shall not be increased above the natural water temperature by more than 2.2°C (3.96°F) during other months
	• In no case exceed 32°C (89.6°F) due to discharge of heated liquids

Source: Environmental Management Commission. 1979. North Carolina Administrative Code, Title 15, Department of Natural and Economic Resources, Chapter 2, Subchapter 2B, Section 0.200.

Appendix Table 2.1.2.1.c. Water Quality Standards for Contact Recreational Waters (Class SB) of North Carolina.

Parameter	Standard
Floating solids, settleable solids, sludge	Not attributable to sewage, industrial or other wastes
Sewage, industrial wastes Other wastes	None which are not effectively treated to the satisfaction of the Commission
pH	6.0<pH<8.5, swamp waters as low as 4.3
Dissolved Oxygen	>5.0 mg/l, unless attributable to natural conditions
Toxic wastes, oils, deleterious substances, colored or other wastes	• Only levels above or in combination which will not make waters unsafe or unsuitable for fish and shellfish or affect the potential for bathing • Or impair palatability of the fish or shellfish • Or impair waters for other best usage established
Fecal coliform (May-September)	• Log mean less than 200/100 ml MPN or MF count on at least 5 consecutive samples examined over a 30 day period • not to exceed 400/100 ml in more than 20 percent samples examined during a 30 day period. (not applicable during or immediately following periods of rainfall)
Temperature	• Shall not be increased above the natural water temperature by more than 2.2°C (3.96°F) during other months • in no case exceed 32°C (89.6°F) due to discharge of heated liquids

Source: Environmental Management Commission. 1979. North Carolina administrative Code, Title 15, Department of Natural and Economic Resources, Chapter 2, Subchapter 2B, Section 0.200.

Table 2.1.2.1.d. Water Quality Standards for Fishing and Secondary Recreation Waters (Class SC) of North Carolina.

Parameter	Standard
Floating solids, settleable solids, sludge	Only amounts attributable to sewage, industrial wastes or other wastes that after dilution will not make receiving waters unsafe or unsuitable for fish, shellfish and wildlife or impair waters for other best usage.
pH	$6.0 < pH < 8.5$, swamp waters as low as 4.3
Dissolved Oxygen	>5.0 mg/l, unless attributable to natural conditions
Toxic wastes, oils, deleterious substances, colored or other wastes	• Only levels above or in combination which will not make waters unsafe or unsuitable for fish and shellfish, or their propagation • or impair palatability of the fish or shellfish • or impair waters for other best usage established
Fecal coliform	• Log mean less than 1000/100 ml MPN or MF based upon at least 5 consecutive samples examined during any 30 day period. • Not to exceed 2000/100 ml in more than 20 percent of the samples during a 30 day period (not applicable during or immediately following rainfall).
Temperature	• Shall not be increased above the natural water temperature by more than 2.2°C (3.96°F) during other months • in no case exceed 32°C (89.6°F) due to discharge of heated liquids.

Reference: Environmental Management Commission. 1979. North Carolina administrative Code, Title 15, Department of Natural and Economic Resources, Chapter 2, Subchapter 2B, Section 0.200.

Appendix Table 2.1.2.1.e. North Carolina Ambient Water Quality Standards and Guidelines Violated between January 1978 and January 1981 Compared against USEPA recommended Criteria for Protection of the Aquatic Environment.

Parameter-units	Standard	Guideline	USEPA Criteria
Total Kjeldahl Nitrogen; mg/l-N	-	0.5	-
NH_3/NH_4; mg/l-N	-	0.5	0.02 mg/l as[1] unionized NH_3
NO_2/NO_3; mg/l-N	-	0.3	-
Orthophosphorus; mg/l-P	-	0.05	-
Total Phosphorus; mg/l-P	0.1	0.05	0.36[2]
pH; (Su)	-	6.8-8.5	6.5-8.5[3,1]
BOD_5; mg/l	-	5	-
DO; mg/l	<5	<5	Water should contain sufficient oxygen to maintain aerobic conditions in the water column except as affected by natural phenomena at the sediment-water interface.
Fecal Coliform; #/100 ml	400	400	• Bathing Waters[1,8] - Not greater thana log mean of 200/100 ml based on a minimum of 5 samples collected over 30 days - Not more than 10% of samples exceed 400/100 ml • Shellfish Waters[1,9] - Not exceed 14 MPN/100 ml - Not more than 10% exceed 43 MPN/100 ml
Total Coliform; #/100 ml	-	70	-
Total Aluminum; ug/l	-	100	<1500 Hazardous[2,4] >200 Minimum Risk[2,4]
Total Copper, ug/l	-	40	<50 Hazardous[2,4] >10 Minimal Risk[2,4]

Appendix Table 2.1.2.1.e. Continued

Parameter-units	Standard	Guideline	USEPA Criteria
Total Iron; ug/l	-	1000	>300 Hazardous[2] <50 Minimal Risk[2]
Total Mercury; ug/l	0.10	0.05	0.20[1]
Total Lead; ug/l	-	100	<50 Hazardous[2,4] <10 Minimal Risk[2,4]
Total Zinc; ug/l	-	50	<100 Hazardous[2,4] <20 Minimal Risk[2,4]
Total Manganese; ug/l	-	100	>100 Haardous[2,4] <200 Minimal Risk[2,6]
Total Cobalt; ug/l	-	100	-
Total Nickel; ug/l	100	100	>100 Hazardous[2,7] ≤ 2 Minimal Risk[2,7]
Total Chloride	-	250	-

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1. Quality Criteria for Water - July 1976 (EPA Red Book)
2. USEPA Blue Book Water Quality Criteria 1972 (EPA Blue Book)
3. But not more than 0.2 units outside normally occurring range
4. Concentration should not exceed (0.01) x (96 hours LC 50) of most sensitive species. LC 50 = concentration at which 50 percent of test organisms die.
5. 24 hour concentration not exceed (0.01) x (96 hours LC 50); never exceed (0.02) (96 hour LC 50) of most sensitive species.
6. Recommended concentration should not exceed (0.02) (96 hour LC 50) of most sensitive species.
7. USEPA Red Book also recommends concentration not exceeded (0.02) (96 hour LC 50) of most sensitive species.
8. This is similar to North Carolina's Standards for SB waters.
9. This is the federal criteria for shellfish waters and, although not officially adapted, is also used as a guideline by the Department of Human Resources, Division of Health Services, to open and close shellfish waters.

Appendix Table 2.1.2.2 Number of Violations of Water Quality Standards and Guidelines at Ambient Network Stations in the Vicinity of the North Carolina Barrier Islands Between January 1978 and January 1981.

		Violations of Standard/Violations of Guidelines/Approx. # of Samples[1]						
Station	Location	Fecal Coliform	Total Coliform	Total Aluminum	Total Copper	Total Iron	Total Mercury	Total Lead
3-02084633	Pamlico Sound at Knoll Island near Ocracoke, N.C.	1/1/12	-/3/12	-/1/12	-/3/12	-/0/12	4/4/12	-/6/12
4-02084632	Pamlico Sound near Frisco, N.C.	0/0/12	-/4/12	-/0/12	-/4/12	-/0/12	2/2/12	-/7/12
5-02084631	Pamlico Sound at Great Island near Buxton, N.C.	1/1/12	-/13/12	-/0/12	-/2/12	-/0/12	3/3/12	-/10/12
6-02084630	Pamlico Sound at Jade Shoal Island near Rodanthe, N.C.	1/1/12	-/6/12	-/0/12	-/2/12	-/0/12	3/3/12	-/7/12
7-0108117980	Roanoke Sound at Herring Shoal Island near Oregon Inlet	1/1/12	-/10/12	-/0/12	-/0/12	-/0/12	4/4/12	-/7/12
8-0208117975	Roanoke Sound at Manteo, N.C.	1/1/36	-/18/36	-/2/12	-/1/12	-/1/12	2/2/12	-/2/12
9-0208117975	Croatan Sound at Manteo, N.C.	0/0/36	-/16/36	-/0/12	-/1/12	-/1/12	4/4/12	-/2/12
10-02042955	Currituck Sound at Point	0/0/36	-/9/36	-/0/12	-/0/12	-/3/12	3/3/12	-/0/12
11-0204295490	Currituck Sound at Aydleleth, N.C.	0/0/12	-/2/12	-/1/12	-/1/12	-/1/12	2/2/12	-/0/12
12-0209270790	N. River off Carrott Island at Beaufort, N.C.	0/0/36	-/0/36	-/0/12	-/4/12	-/0/12	1/1/12	-/5/12
13-02092727	Newport River at U.S. Highway to near Morehead City, N.C.	0/0/36	-/0/36	-/0/12	-/4/12	-/1/12	1/2/12	-/5/12
14-0209270940	Bogue Sound at Emerald Isle,	0/0/36	-/0/36	-/0/12	-/4/12	-/2/12	0/0/12	-/5/12
15-02092760	White Oak R. at Swansboro, N.C.	0/0/36	-/0/36	-/0/12	-/4/12	-/2/12	0/0/12	-/5/12
18-0209320420	AIWW at Goose Bay near Holly Ridge, N.C.	0/0/36	-/0/36	-/0/12	-/3/12	-/0/12	-/1/12	-/3/12
19-0209320550	AIWW at N.C. 210 at Surf City, N.C.	2/2/36	-/0/36	-/0/12	-/4/12	-/0/12	-/1/12	-/4/12
20-0209320750	Topsail Sound at Topsail, N.C.	1/1/36	-/1/36	-/0/12	-/3/12	-/0/12	2/2/12	-/5/12
21-021088150	AIWW near Carolina Beach, N.C.	0/0/36	0/0/36	-/0/12	-/1/12	-/0/12	2/2/12	-/2/12
23-0210891640	Lockwoods Folly R. near Supply, N.C.	0/0/36	-/0/36	-/0/12	-/0/12	-/0/12	1/1/12	-/0/12
24-0210892500	AIWW near Varnum's Landing, N.C.	0/0/36	-/1/36	-/0/12	-/3/12	-/0/12	2/2/12	-/3/12

Table 2.1.2.2 Continued

Station	Location	Violations of Standard/Violations of Guidelines/Approx. # of Samples[1]						
		Fecal Coliform	Total Coliform	Total Aluminum	Total Copper	Total Iron	Total Mercury	Total Lead
25-02108956	Calabash Creek near NC/SC line	0/0/36	-/1/36	-/0/12	-/3/12	-/0/12	2/2/12	-/3/12
26-0210895300	AIWW at Seaside	0/0/36	-/0/36	-/0/12	-/3/12	-/1/12	1/2/12	-/3/12

Appendix Table 2.1.2.2. Continued

Station	Location	Violations of Standard/Violations of Guidelines/Approx. # of Samples[1]							
		TKN	NH_3/NH_4	NO_2/NO_3	Ortho-P	Total-P	pH	BOD_5	DO
3-02084633	Pamlico Sound at Knoll Island near Ocracoke, N.C.	-/4/12	-/6/12	-/0/12	-/4/12	0/0/12	-/0/12	1/1/36	0/0/12
4-02084632	Pamlico Sound near Frisco, N.C.	-/4/12	-/3/12	-/0/12	-/1/12	1/7/12	-/0/12	-/4/36	0/0/12
5-02084631	Pamlico Sound at Great Island near Buxton, N.C.	-/8/12	-/5/12	-/2/12	-/0/12	0/6/12	-/1/12	-/5/36	0/0/12
6-02084630	Pamlico Sound at Jade Shoal Island near Rodanthe, N.C.	-/5/12	-/1/12	-/3/12	-/1/12	2/7/12	-/1/12	-/1/36	0/0/12
7-0108117980	Roanoke Sound at Herring Shoal Island near Oregon Inlet	-/1/12	-/8/12	-/1/12	-/0/12	-/2/12	-/0/12	1/2/36	0/0/12
8-0208117975	Roanoke Sound at Manteo, N.C.	-/4/12	-/3/12	-/1/12	-/0/12	1/4/12	-/0/12	-/2/36	0/0/12
9-0208117975	Croatan Sound at Manteo, N.C.	-/5/12	-/1/12	-/0/12	-/0/12	0/0/12	0/0/36	-/0/36	0/0/36
10-02042955	Currituck Sound at Point Harbor, N.C.	-/6/12	-/1/12	-/0/12	-/0/12	2/4/12	-/1/36	-/1/36	0/0/36
11-0204295490	Currituck Sound at Aydleleth, N.C.	-/0/12	-/3/12	-/1/12	-/0/12	2/4/12	-/3/12	-/3/36	1/1/12
12-0209270790	N. River off Carrott Island at Beaufort, N.C.	-/2/12	-/3/12	-/0/12	-/0/12	0/2/12	-/6/36	-/1/36	0/0/36
13-02092727	Newport River at U.S. Highway to near Morehead City, N.C.	-/3/12	-/3/12	-/1/12	-/1/12	0/1/12	-/1/36	-/1/36	0/0/36
14-0209270940	Bogue Sound at Emerald Isle, N.C.	-/2/12	-/1/12	-/0/12	-/0/12	0/2/12	-/12/36	-/0/36	0/0/36
15-02092760	White Oak R. at Swansboro, N.C.	-/2/12	-/2/12	-/1/12	-/0/12	0/0/12	-/5/36	-/1/36	0/0/36
18-0209320420	AIWW at Goose Bay near Holly Ridge, N.C.	-/1/12	-/2/12	-/1/12	-/1/12	-/3/12	-/14/36	-/1/36	0/0/36
19-0209320550	AIWW at N.C. 210 at Surf City, N.C.	-/3/12	-/0/12	-/1/12	-/0/12	1/3/12	-/13/36	-/1/36	0/0/36
20-0209320750	Topsail Sound at Topsail, N.C.	-/2/12	-/1/12	-/1/12	-/0/12	0/2/12	-/14/12	-/1/36	0/0/36

Appendix Table 2.1.2.2. Continued

		Violations of Standard/Violations of Guidelines/Approx. # of Samples[1]							
Station	Location	TKN	NH_3/NH_4	NO_2/NO_3	Ortho-P	Total-P	pH	BOD_5	DO
21-0210881050	AIWW near Carolina Beach, N.C.	-/1/12	-/1/12	-/1/12	-/0/12	0/4/12	-/0/36	-/0/36	0/0/36
23-0210891640	Lockwoods Folly R. near Supply, N.C.	-/0/1/12	-/1/12	-/2/12	-/0/12	0/1/12	-/0/36	-/0/36	0/0/36
24-0210892500	AIWW near Varnum's Landing, N.C.	-/2/12	-/3/12	-/1/12	-/0/12	-/3/12	-/6/36	-/0/36	0/0/36
25-02108956	Calabash Creek near NC/SC line	-/1/12	-/3/12	-/0/12	-=/1/12	2/4/12	-/11/36	-/1/36	0/0/36
26-0210895300	AIWW at Seaside	-/1/12	-/2/12	-/2/12	-/0/12	-/3/12	-/8/36	-/1/36	0/0/36

Appendix Table 2.1.2.2. Continued

Station	Location	Violations of Standard/Violations of Guidelines/Approx. # of Samples[1] Total Zinc	Total Manganese	Total Cobalt	Total Chloride	Total Nickel
3-02084633	Pamlico Sound at Knoll Island near Ocracoke, N.C.	-/5/12	-/2/12	-/2/12	-/2/12	0/0/12
4-02084632	Pamlico Sound near Frisco, N.C.	-/4/12	-/0/12	-/1/12	-/0/12	1/1/12
5-02084631	Pamlico Sound at Great Island near Buxton, N.C.	-/4/12	-/0/12	-/1/12	-/0/12	-/0/12
6-02084630	Pamlico Sound at Jade Shoal Island near Rodanthe, N.C.	-/1/12	-/0/12	-/1/12	-/0/12	0/0/12
7-0108117980	Roanoke Sound at Herring Shoal Island near Oregon Inlet	-/2/12	-/0/12	-/2/12	-/0/12	0/0/12
8-0208117975	Roanoke Sound at Manteo, N.C.	-/1/12	-/0/12	-/0/12	-/0/12	0/0/12
9-0208117975	Croatan Sound at Manteo, N.C.	-/1/12	-/0/12	-/0/12	-/0/12	0/0/12
10-02042955	Currituck Sound at Point Harbor, N.C.	-/1/12	-/2/12	-/0/12	-/4/12	0/0/12
11-0204295490	Currituck Sound at Aydleleth, N.C.	-/2/12	-/0/12	-/0/12	-/4/12	0/0/12
12-0209270790	N. River off Carrott Island at Beaufort, N.C.	-/0/12	-/0/12	-/6/12	-/4/12	0/0/12
13-02092727	Newport River at U.S. Highway to near Morehead City, N.C.	-/0/12	-/1/12	-/6/12	-/3/12	-/0/12
14-0209270940	Bogue Sound at Emerald Isle, N.C.	-/1/12	-/0/12	-/5/12	-/2/12	0/0/12
15-02092760	White Oak R. at Swansboro, N.C.	-/1/12	-/0/12	-/2;12	-/1/12	0/0/12
18-0209320420	AIWW at Goose Bay near Holly Ridge, N.C.	-/1/12	-/1/12	-/3/12	-/2/12	0/0/12
19-0209320550	AIWW at N.C. 210 at Surf City, N.C.	-/2/12	-/2/12	-/5/12	-/2/12	0/0/21
20-0209320750	Topsail Sound at Topsail, N.C.	-/0/12	-/3/12	-/4/12	-/4/12	0/0/12
21-0210881050	AIWW near Carolina Beach, N.C.	-/0/12	-/3/12	-/1/12	-/1/12	0/0/12
23-0210891640	Lockwoods Folly R. near Supply, N.C.	-/0/12	-/3/12	-/0/12	-/1/12	0/0/12

Appendix Table 2.1.2.2. Continued

Station	Location	Total Zinc	Total Manganese	Total Cobalt	Total Chloride	Total Nickel
		Violations of Standard/Violations of Guidelines/Approx. # of Samples[1]				
24-0210892500	AIWW near Varnum's Landing, N.C.	-/1/12	-/0/12	-/3/12	-/1/12	0/0/12
25-02108956	Calabash Creek near NC/SC line	-/1/12	-/0/12	-/2/12	-/2/12	0/0/12
26-0210895300	AIWW at Seaside	-/2/12	-/1/12	-/3/12	-/3/12	0/0/12

(1) "-" No Standard to be violated
"0" There is a standard or guideline to be violated but no violations were recorded
Violations of Standard: The numbers provided under this heading indicate the number of times a State Water Quality Standard has been violated between January 1978 and January 1981.
Violations of Guideline: The numbers provided under this heading indicate the number of times a designated guideline has been violated between January 1978 and January 1981.
Approximate Number of Samples : The numbers provided under this heading indicate the approximate number of times this parameter was monitored at each station.

Appendix 2.1.2.4 Findings of 1978-1979 Sanitary Surveys

Southport. Homes using septic systems on Oak Island along Yaupon Beach are located in this drainage area. This area also drains marsh land from the barrier island and the mainland as well as areas served by septic systems on the mainland. It is not possible to distinguish which of the above sources is the key contributor to pollution. High bacterial counts are also observed immediately below the wastewater treatment outfall and the port of Southport. How much this area is influenced by the polluted waters of the Cape Fear River cannot be readily discerned. A more detailed study is necessary if it is to be determined how important septic systems on Yaupon Beach are in contributing to bacterial pollution of shellfish waters. However, it can be said that most of this development is on filled-in marsh. This implies a great possibility for bacterial pollution, especially after rainfall events, since they can be associated with high bacterial counts found in the Intracoastal Waterway.

Wrightsville Beach. Most high bacterial counts originate from mainland drainage which contains marsh, septic systems and sewer outfalls. There is some pollution around the Harbor Island docks. However, results of drogue studies conducted by the Shellfish Sanitation Office indicate that it is difficult to distinguish whether the pollution is from the mainland and/or marinas. High bacterial counts are observable in the vicinity of the Wrightsville Beach wastewater treatment plant outfall. It is understood that this treatment plant has since been improved. Once again, high bacterial counts appear to be rain event related with rainfall occurring on or immediately prior to the day of sampling. In the sound directly adjacent to Wrightsville Beach, bacterial counts are low; however, the excellent tidal flushing in this area may dilute pollution.

Topsail. The highest bacterial counts appear to originate from the mainland creeks, which drain marshes and areas served by septic tanks. There are a few instances of possible pollution from septic tanks located toward Surf City. High bacterial counts are generally associated with rainfall events.

Surf City. A number of sites at Surf City immediately adjacent to the access bridge exhibit high coliform counts. Marinas and the Surf City finger fill canal development, serviced by septic tanks, also exhibited high counts. High coliform counts were associated with rainfall events. Bacterial counts tended not to be as high as in the previously mentioned studies by USEPA and State of North Carolina. High bacterial counts were also associated with the mainland, especially Kings Creek which receives discharge from the Holly Ridge wastewater treatment plant.

Morehead City/Atlantic Beach. Most of the pollution was found near the unsewered Atlantic Beaches in and around finger fill canal development and near marinas on the north and south side of the access bridge to Atlantic Beach. Pollution from Morehead City proper, which is sewered, appears to be minor, occurring in the vicinity of marinas and docks. A sizable amount of bacterial pollution is found in Peltier Creek. Homes along the creek are served by septic tanks. However, in the opinion of the Shellfish Sanitation Office (Gilbert 1981), these high bacterial counts are primarily due to marinas and a large amount of boat traffic in Peltier Creek. As before, high bacterial counts are associated with rainfall events.

Beaufort. Beaufort, like Morehead City, is sewered and had the lowest bacterial counts of all areas analyzed. Taylor's Creek, which receives discharge from the city's wastewater treatment facility and a number of fish processing facilities, exhibited very low bacterial counts even after rainfall events. This may be due to the extensive flushing that occurs in this creek (Schmidt 1981). High bacterial counts, when they occurred, were typically seen around docks and marinas and below Carrot Island. Based upon the sanitary survey, these appear to originate from marsh drainage and cattle or horse pastures. Rainfall events did not appear tc have a major effect on bacterial counts in this area.

Hatteras/Outer Banks. Most counts near the town of Hatteras are associated with the immediate vicinity of the town, which is served by septic tanks, and with marinas. Additionally some pollution is suspected from waterfowl. Most of the high bacterial counts are associated with the towns of Buxton, Salvo, Rodanthe and Avon. In waters near undeveloped areas north and south of these towns, counts on the same sampling day are low even through migratory waterfowl use these sites as wintering grounds. However, Shellfish Sanitation Office staff believe high counts in many cases are associated with feces from gulls that are attracted to the towns to feed on scraps of dead fish deposited in and around these towns (Gilbert 1981). If gulls are the problem, then high bacterial counts could be expected in these waters during non-rain events as well as during the winter months when large numbers of migratory waterfowl are in the area. In neither instance does this appear to be the case. Additionally, fecal coliform counts are in many cases very high. The sanitary survey rules out boats as being a major cause of pollution. Therefore, septic tank systems in this area could be a major source of pollution, especially after rainfall events.

Appendix Table 2.2.4. Checklist of Birds from the Barrier Islands of North Carolina

SEASONS
- Spring - March to May
- Summer - June to August
- Fall - September to November
- Winter - December to February

STATUS
- C - Common. Seen almost all the time in the proper season and habitat.
- F - Fairly Common. Seen most of the time in the proper season and habitat.
- U - Uncommon. Not certain to be seen at any time of the year in the proper season and habitat.
- O - Occasional. Seen only a few times in a year.
- R - Rare. Seen only every few years, perhaps from three to ten times.

HABITATS
- o - offshore ocean
- i - inshore ocean
- b - ocean beach
- d - vegetated dunes
- t - shrub thicket
- p - pine forest
- w - maritime forest
- f - freshwater marshes, ponds and swamps
- s - saltmarsh
- m - mudflat
- q - sound waters
- a - aerial

COMMON NAME	SEASONAL STATUS				HABITATS
	S	S	F	W	
Common loon	C	O	C	C	i f q
Red-throated Loon	C	R	C	C	i
Red-necked Grebe				R	i
Horned Grebe	F		C	C	i q
Pied-billed Grebe	C	U	C	C	f
Cory's Shearwater	R	U	U		o
Greater Shearwater		O	U	R	o
Sooty Shearwater	F	U	R		o
Audubon's Shearwater		F	F		o
Leach's Storm-petrel		R	O		o
Wilson's Storm-petrel	O	F	F		o
Brown Pelican	R	F	C	O	i q
Gannet	C	R	C	C	o i
Double-crested Cormorant	C	O	C	C	i q
Great Blue Heron	F	U	F	F	w s m
Green Heron	F	U	F	O	f
Little Blue Heron	C	C	C	U	f s
Cattle Egret	U	C	C	O	f s
Great Egret	C	C	C	F	f s

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	S	F	W	HABITATS
Snowy Egret	C	C	C	U	f s m
Louisiana Heron	C	C	C	U	f s
Black-crowned Night Heron	C	C	C	C	b f s m
Yellow-crowned Night Heron	O	U	U	O	f s
Least Bittern	U	U	U		f s
American Bittern	C	R	C	F	f s
Glossy Ibis	C	C	CS	O	f s m
White Ibis	R	SO	O	O	f s
Whistling Swan	F	R	F	F	f
Canada Goose			R	R	f s
White-fronted Goose				R	f
Snow Goose	C	O	C	C	f s q
Fulvous Whistling Duck	O		U	U	f
Mallard	U	O	U	U	f q
Black Duck	C	F	C	C	f s q
Gadwall	C	C	C	F	f
Pintail	C		C	C	f q
Blue-winged Teal					i f s
Green-winged Teal	C	O	C	O	f
American Wigeon	C		C	C	f
European Wigeon	R		R	R	f
Northern Shoveler	C		C	C	f m s
Wood Duck	R	U	U	R	f w
Redhead	U		F	F	f q
Ring-necked Duck	F		F	F	f q
Canvasback	F		F	F	f q
Greater Scaup	F		F	F	f q
Lesser Scaup	F		U	F	f q
Common Goldeneye	r		R	O	f q
Bufflehead	C	R	C	C	f s
Oldsquaw	U		R	U	i q
King Eider			R	R	i
White-winged Scoter	U		U	F	i
Surf Scoter	F		U	C	i
Black Scoter	C		U	C	i
Ruddy Duck	F	R	F	F	f q
Hooded Merganser	U		U	C	f
Common Merganser	U		U	U	f
Red-breasted Merganser	C	R	C	C	i q
Turkey Vulture	R	R	R	R	a
Black Vulture	R	R	R	R	a
Swallow-tailed Kite	R	R			p w f
Sharp-skinned Hawk	O		F	U	t p w a
Cooper's Hawk	R		U	O	p w a
Red-tailed Hawk	F		F	U	a t w
Red-shouldered Hawk	F	F	F	F	w
Bald Eagle	R	R	O	R	f q p
Marsh Hawk	C	R	C	C	d f s
Osprey	U	U	U		f q

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	S	F	W	HABITATS
Peregrine Falcon	U		U	U	a b d s
Merlin	U		U	U	d t p s
American Kestrel	C		C	C	d t
Ring-necked Pheasant	C	C	C	C	d t
Bobwhite	U	U	U	U	t p w
King Rail	C	C	C	F	f
Clapper Rail	C	C	C	F	s m
Virginia Rail	U	0	U	U	f s
Sora	C	U	C	U	f s
Yellow Rail	R		R	R	f s
Black Rail	R	R	R	R	f s
Purple Gallinule	R	R			f
Common Gallinule	U	U	U	0	f
American Coot	C	R	C	C	f s m q
American Oystercatcher	F	F	F	R	b s m
Semipalmated Plover	C	0	C	U	s m
Piping Plover	F	U	F	U	b
Wilson's Plover	U	0	U	U	b s m
Killdeer	U	0	U	U	d f s m
American Golden Plover	R		0	R	b s m
Black-bellied Plover	C	U	C	C	b m
Ruddy Turnstone	C	U	C	F	b m
American Woodcock	R		R	R	t p f
Common Snipe	C		C	C	f m
Whimbrel	0		F	0	b s m
Long-billed Curlew				0	s m
Upland Sandpiper	R		0		d f s
Spotted Sandpiper	C	U	C	0	f m
Solitary Sandpiper	U		U	0	f
Willet	C	C	C	0	b f s m
Greater Yellowlegs	C	C	C	U	f s m
Lesser Yellowlegs	C	C	C	U	f s m
Red Knot	C	U	F	R	b m
Pectoral Sandpiper	U		C	R	f s m
White-rumped Sandpiper	0	R	F		s m
Baird's Sandpiper	C	F	C	0	f s m
Dunlin	C		C	C	m
Short-billed Dowitcher	C	F	C	U	m
Long-billed Dowitcher	0	R	F	U	m
Stilt Sandpiper	0		F	R	f s m
Semipalmated Sandpiper	C	F	C		s m
Western Sandpiper	F	U	C	0	s m
Buff-breasted Sandpiper		0		f s	
Marbled Godwit	0	U	F	0	b m s
Hudsonian Godwit	R		U		b m
Sanderling	C	F	C	C	b m
American Avocet	U	F	F	F	f s m
Black-necked Stilt	F	C	C		f s
Red Phalarope	U		U		o

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	S	F	W	HABITATS
Wilson's Phalarope	R		O		f s
Northern Phalarope	R		O		o i s q
Pomarine Jaeger			U	R	o i
Parasitic Jaeger	U		U	U	o i
Glaucous Gull	R			U	i b q a
Great Black-backed Gull	F	O	C	C	i b q a
Herring Gull	C	F	C	C	i b q s a
Ring-billed Gull	C	F	C	C	i b q f s
Laughing Gull	C	C	C	U	i b q s a
Bonaparte's Gull	C		U	C	i b s
Black-legged Kittiwake	O		O	U	o i b a
Gull-billed Tern	F	F	U		d f s
Forster's Tern	C	F	C	C	i f s q
Common Tern	C	C	C	O	i f q o
Roseate Tern	O		O		i q o
Least Tern	C	C	C		i f s q
Royal Tern	C	C	C	F	i s q
Sandwich Tern	F	F	F	R	i s q
Caspian Tern	U	U	C	R	f q
Bridled Tern		O	U	R	o
Black Tern	U	C	C		f s q
Black Skimmer	F	F	C	O	i f s q
Razorbill				R	o i
Dovekie	O			U	o i
Mourning Dove	C	C	C	C	d t w
Ground Dove					d t w
Yellow-billed Cuckoo	U	U	F		t p w
Black-billed Cuckoo	R		R		p w
Barn Owl	U	O	U	U	d t p w s
Screech Owl	U	U	U	U	w
Short-eared Owl	U		U	F	d s f
Chuck-will's-widow	F	F			p
Whip-poor-will					w
Common Nighthawk	F	U	F	C	f s q
Chimney Swift	U	U	U		a
Ruby-throated Hummingbird	O	O	O		w d
Belted Kingfisher	F	U	F	C	f s q
Common Flicker	U	U	C	F	t w p
Red-headed Woodpecker	O	O	O		w
Yellow-bellied Sapsucker	U		F	F	p w
Red-bellied Woodpecker					w
Hairy Woodpecker	U		U	U	p
Downy Woodpecker	F	F	F	F	p w t
Eastern Kingbird	C	C	C		d t
Western Kingbird			U		d t
Great-crested Flycatcher	F	U	F	R	w
Eastern Phoebe	F		F	U	p w
Yellow-bellied Flycatcher			R		t p w
Least Flycatcher					w t

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	S	F	W	HABITATS
Acadian Flycatcher			R		t w
Eastern Wood Pewee	U	U	U		p t w
Olive-sided Flycatcher			0		p t
Horned Lark	R		R	R	d
Tree Swallow	F	F	C	U	p f a
Bank Swallow	0		U		f a
Rough-winged Swallow			R		f a
Barn Swallow	C	C	C		a d t
Cliff Swallow			0		a
Purple Martin	F	F	F		a d p
Blue Jay	F	F	F		w p
Common Crow	U	U	U	U	w
Fish Crow	F	F	F	F	b d t f s
Carolina Chickadee	F	F	F	F	p w
White-breasted Nuthatch			R	R	w
Red-breasted Nuthatch	F		F	F	p
Brown-headed Nuthatch	U	U	U	U	p
Brown Creeper	0		F	F	p
House Wren	U		F	F	w t
Winter Wren	0		U	U	t
Carolina Wren	C	C	C	C	t p w
Long-billed Marsh Wren	C	C	C	C	f s
Short-billed Marsh Wren	C		C	C	f s
Mockingbird	C	C	C	C	t w p d
Gray Catbird	C	C	C	C	t w p
Brown Thrasher	F	F	F	F	t w
American Robin	C	0	C	C	p d t
Wood Thrush			U		w t
Hermit Thrush	U		F	F	t p w
Swainson's Thrush	0		C		t p
Gray-cheeked Thrush	0		F		t w p
Veery					w
Blue-gray Gnatcatcher	U	U	U	R	w t
Golden-crowned Kinglet	U		F	F	p
Ruby-crowned Kinglet	U		F	F	p
Water Pipit	U		U	U	d m
Cedar Waxwing	U		F	C	t w p
Loggerhead Shrike			R	R	d t
Starling	C	C	C	C	t w
White-eyed Vireo	C	C	C		t p
Solitary Vireo			R		t w
Red-eyed Vireo	U	U	U		w t
Philadelphia Vireo			0		w t
Black-and-white Warbler	U		F		w p
Prothonotary Warbler	F	F	F		p w
Worm-eating Warbler					w
Tennessee Warbler	R		U		w t
Golden-winged Warbler					w

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	 S	 F	 W	HABITATS
Orange-crowned Warbler	U		U	U	t
Nashville Warbler			U		t
Northern Parula Warbler	U		F		t w p
Yellow Warbler	U	0	F		w t
Magnolia Warbler	0		C		t p
Cape May Warbler			F		t p w
Black-throated Blue Warbler	U		F	R	t p w
Black-throated Green Warbler			U		p t
Yellow-rumped Warbler	C		C	C	t p d w
Blackburnian Warbler			0		t p w
Yellow-throated Warbler			R		t
Chestnut-sided Warbler			U		t w
Bay-breasted Warbler			U		t p
Blackpoll Warbler			F		t p w
Pine Warbler	C	C	C	0	p t
Prairie Warbler	C	C	C		p t w
Palm Warbler	C		C	U	t d
Ovenbird	R		U		t w
Northern Waterthrush	U		C		t f w
Louisiana Waterthrush	U		U		t f
Mourning Warbler					w
Connecticut Warbler			U	R	t
Yellowthroat	C	C	C	U	t f s w
Yellow-breasted Chat	U	U	U	0	t w f
Hooded Warbler			0		t w
Wilson's Warbler			0		t w
Canada Warbler		0		t p	
American Redstart	F		C		p t w d
House Sparrow	U	U	U	U	t d
Bobolink	F		F		d f s
Eastern Meadowlark	C	C	C	C	d t
Red-winged blackbird	C	C	C	C	f t s
Orchard Oriole	0	0	0		w
Northern Oriole			C		w
Rusty Blackbird			0	0	f t d s
Boattailed Grackle	U	R	U	U	t d p
Common Grackle	U	U	F	U	w d t
Brown-headed Cowbird	U	R	U	U	w
Scarlet Tanager			0		w
Summer Tanager	U	0	0		w p
Cardinal	C	C	C	C	t w p
Rose-breasted Grosbeak	U		U		w
Blue Grosbeak	U	0	U		t w f
Indigo Bunting	U	0	U		t w
Dickcissel			0		d t
Evening Grosbeak			0	0	t p
Painted Bunting	0				t w
Purple Finch			U	F	t p
Common Redpoll			R	R	t p d

Appendix Table 2.2.4 Continued

COMMON NAME	SEASONAL STATUS S	S	F	W	HABITATS
Pine Siskin			F	C	p t
American Goldfinch	U		C	U	t w
Red Crossbill				R	p
Rufous-sided Towhee	F	F	F	F	t w p
Ipswich Sparrow					d
Savannah Sparrow	C		C	C	d t
Grasshopper Sparrow			U	O	d t
LeConte's Sparrow	R			R	t f
Sharp-tailed Sparrow	C		C	C	s f
Seaside Sparrow	F	F	F	F	s
Vesper Sparrow			C	U	d t
Lark Sparrow			U	U	d t
Backman's Sparrow		R			p
Dark-eyed Junco			F	F	p t d
Chipping Sparrow	O		F	U	t p
Clay-colored Sparrow			U		t d
Field Sparrow	U	O	F	F	t d w
White-crowned Sparrow			F	O	t p
White-throated Sparrow	F		F	C	t p w
Fox Sparrow	O		U	U	t p
Lincoln's Sparrow			U	O	t f
Swamp Sparrow	U		C	C	f t s
Song Sparrow	C	C	C	C	t f d
Lapland Longspur			O	R	d
Snow Bunting	O		O	U	d

Source: U.S. Dept. of Interior, National Park Service (undated).
Parnell and Adams 1970.

APPENDIX 3.3.3

SITING CRITERIA FOR CONVENTIONAL/ALTERNATIVE ON-SITE SYSTEMS

Rubin, A. R. 1981. North Carolina State University Agricultural Extension Service.

Several factors will affect the acceptability of on-site systems on barrier islands. Soils, geology, and topography are some of the more important criteria. Based on geological characteristics, North Carolina may be divided into two general regions. The easternmost region consists chiefly of unconsolidated rock materials which for the most part were deposited in the Atlantic Ocean and formed the ocean floor until elevated to its present location. The second region of North Carolina is the western region and it is composed primarily of consolidated rock. The eastern region is known as the Coastal Plain and the western region as the Appalachian Highlands. The Coastal Plain, which occupies approximately 45% of the land area in the state of North Carolina, may be divided into seven distinct regions. These divisions are based upon the seven distinct marine terraces which formed during the Quaternary.

The Coastal Plain is a relatively smooth plain ranging in elevation from sea level along the coastal portions to generally less than 300 feet where the Coastal Plain borders the Piedmont Plateau. Coastal Plain deposits of unconsoidated rock constitute the youngest geologic formations in North Carolina and can vary in thickness from a very thin veneer at the western edge to several thousand feet near the coast.

The Coastal Plain is considered as having three rather broad distinctive units. These units are distinguished principally by elevation and relief and to some degree by soils. They are the lower or tidewater unit on the easternmost boundary of the Coastal Plain, with the middle and the upper Coastal Plain units, respectively, to the east. The barrier island are characteristically in the easternmost or tidewater portion of the Coastal Plain.

There is little overall relief in the tidewater although occasionally low ridges and gentle slopes may prevail. Few elevations in the barrier islands exceed 25 feet. The quaternary deposits forming the barrier islands are the youngest soil forming materials found in North Carolina. Because of this, the soils of the Outer Banks are poorly developed granular and single grained soils.

The principal problems associated with these soils for on-site systems include high permeability and high water table. A large percentage of the soils considered unsuitable along the Outer Banks are unsuitable because the water table is located at least as close as 12 inches to the soil surface for three to six months during the year. A second major problem that occurs on the Outer Banks is the highly permeable deep sands. These deep sandy soils have reduced wastewater treatment and purification potentials and potentially will discharge wastewater into the water table. A slightly less common problem along the Outer Banks of North Carolina is soil with high clay content. In all cases, soils with high clay content will provide adequate treatment of effluent, provided the distance between the bottom of the effluent distribution line and the water table is 12 inches or more. The following three conditions constitute the major problems encountered along the Outer Banks:

1. rapidly permeable soils,
2. high water table, and
3. soils with moderately high clay content and high water table.

Detailed descriptions of the more common soil types encountered along the Outer Banks are included in this report. The soils are grouped as:

1. characteristically deep well-drained sands,
2. characteristically sandy poorly-drained soils, and
3. soils with moderately high clay content and high water table.

An up-to-date soil survey has been completed in all of the counties with fringe areas in the Outer Banks. A major problem associated with installation of septic tanks in these soils is that effluent fails to surface and obvious signs of septic tank failure never appear. There are a number of modifications to the conventional septic tank which can be implemented to overcome the soils or site problems commonly encountered along the Outer Banks. These alternatives to conventional systems will be discussed in more detail subsequently. The purpose of these alternative on-site wastewater treatment systems is to overcome conditions which lead to septic tank failures.

While all possible sources of pollutants in coastal waters have not been quantified, failing septic tanks have been identified as a probable cause of some of the pollution. Recent studies by the surveillance division of the North Carolina Department of Natural Resources and the North Carolina Department of Human Resources (1976) leave little doubt that the proliferation of septic tank effluent disposal systems in specific coastal areas constitutes a threat to proximal coastal water quality and shellfish-growing waters. One study was conducted in Surf City, including the Old Settlers Beach area. Some of the preliminary conclusions of that study were:

1. Dye studies indicate that septic tank systems in the study area contribute significant contamination to nearby shellfish-harvesting waters through both surface and subsurface flows.

2. Surfacing of septic tank effluent and subsequent runoff during periods of rainfall constitute a potential health hazard through possible direct human contact with these wastes and through contact of these wastes with shellfish in the area.

3. The continued dependence upon conventional on-site wastewater treatment and disposal systems for wastewater treatment and disposal in the area will result in further degradation of water resources in the Old Settlers Beach area.

The problem is less well-defined along the remainder of the barrier islands. Nonetheless, the major problem with use of conventional septic systems along the barrier islands is installation of such systems in soils with a seasonally high water table, in soils with excessively permeable sands, with poor filtering capacity and inorganic mucks, with poor hydraulic loading capacity, and relatively low treatment ability.

Soils

Without a thorough knowledge of the soils of the Outer Banks, a scheme for rational planning and development in this area is impossible. It is difficult to develop and manage land resources in any way when that management is inconsistent with the carrying capacities and limitations of that land. At present no quantitative method exists for determining carrying capacity of a given soil body. Carrying capacity refers to the capacity of a given soil body to support a dwelling unit, allow for set-back requirements, and provide sufficient area for both an on-site wastewater treatment/disposal area and an equivalent replacement area. Much of the land area on the Outer Banks is conducive for development; that is, the soils possess characteristics which will permit both the operation of an on-site wastewater treatment system and the support of a building. Conversely, there are areas of the Outer Banks where highly permeable soils, high water table and other site limitations severely restrict the use of those land resources for development.

There are 30 soil mapping units which have been identified on the Outer Banks of North Carolina. Each soil mapping unit may be identified by soil properties and by the vegetation growing on those soils. Proceeding inland from the coast, the first soil body encountered on the Outer Banks is the sandy beach and foredune areas. These are characterized by constantly shifting sands and sparse vegetation. Next are the low lying sandy soils immediately west of the beach and foredunes which are usually wet on the surface and receive large quantities of salt spray from the ocean. Immediately to the west of this the soil characteristics change markedly from north to south. In the north, hilly sandy beach ridges are predominant, while in the south, sandy soils are much less hilly. In both cases the soils contain heavy woody vegetation. The north consists primarily of tall growing pines, while vegetation in the south consists primarily of live oaks.

The need for some comprehensive planning is extremely critical in the coastal zone of North Carolina and most critical on the Outer Banks. A basic tool for this planning is consideration of the limitations posed on development of the soils. A comprehensive planning strategy must incorporate information on soils to decide how land resources can best be managed. A critical property of soils with regard to on-site wastewater treatment is their permeability and their treatment/filtration capacity. Many of the soils of the Outer Banks are unsuitable for conventional on-site wastewater treatment systems. Unsuitable soils are those which are extremely wet, extremely impermeable, or excessively permeable. Reportedly, problems with on-site disposal of septic tank effluent are related to seepage of untreated effluent into ground waters and estuarine waters. Some of these problems may be eliminated through proper sizing and determining carrying capacity of coastal lands for treatment of waste. Research is currently under way in the Soil Science Department at North Carolina State University to assign a carrying capacity to the soils of the Outer Banks of North Carolina. Clearly, development of the finger channels and small 5000 sq. ft. lots is not conducive to environmentally sound development along the coast. This is due primarily to sizing and siting requirements for on-site wastewater treatment systems and to the water table depth encountered on these sites.

A thorough analysis of soils is the cornerstone of a comprehensive development plan. Soils analysis can indicate areas which should not be developed. The presence or absence of certain soil types and soil parameters can act as an indicator of high water table or other conditions which would render a particular site unsuitable for on-site systems.

Soil and Vegetation in the Outer Banks

Soils and dominant vegetation are listed in Table 1. In general, soils and associated vegetation can indicate potential problem sites. But a visual inspection of vegetation is not adequate to determine suitability of a given site. For example, needlerush indicates a wet soil and little can be done to modify that, but waxmyrtle may be present on Newhan Sands and Currituck soil. Thus Newhan is suitable for development while the Currituck probably is not.

Rules and Regulations

In an attempt to overcome these soils and site problems, the North Carolina Commission for Health Services has adopted the Ground Absorption Sewage Disposal Act. Unfortunately, there are numerous problems with these rules, as they will not always effect a reduction in development density on lots already platted or on lots where recorded exemptions from certain requirements (such as set backs from water course and other bodies) have been included. Also, the regulations are aimed primarily at new developments and will have little or no impact on existing septic tank installations.

The rules and regulations promulgated by the state are an attempt to overcome soils and site problems that may lead to failure of septic tank systems. Where the rules of siting septic systems are followed, the incidence of septic system failure should be minimized. There have been no thorough correlation studies to demonstrate the relationship between adherence to rules and success or failure of systems. Usually, the sites most suitable for development have been developed. Many of those remaining do not satisfy all the criteria established for satisfactory performance of systems. Water quality problems and septic tank problems have emerged in areas where all criteria have not been met. Often the problem is not apparent until heavy rains wash potential pollutants through or off land areas adjacent to coastal waters. Unfortunately, on-site systems must operate well even during periods of heavy rain.

The 30 soil mapping units found on the Outer Banks are discussed in the following section. These descriptions together with soils maps (which can be obtained from the local offices of the Soil Conservation Service) can be helpful in determining the potential of a soil for planned land-use activities in an area.

The soil units described in the text are accompanied by Figures 1-14 which depict the soil horizon configurations typical of the particular soil.

TABLE 1. SOILS, PROPERTIES AND ASSOCIATED VEGETATION

Soils	Dominant Texture	Acres (Area)	Depth To Water Table	Infiltration	Permeability	Water Holding	Dominant Vegetation
SOILS, PROPERTIES AND ASSOCIATED VEGETATION OF NORTHERN FOREDUNE							
Beach Sand Foredune Assoc.	Sandy	6,796	0-6'	Rapid	Rapid	Slight	American Beachgrass, Sea Oats, Coastal Panicgrass, Seashore Elder
SOILS, PROPERTIES AND ASSOCIATED VEGETATION OF SOUTHERN FOREDUNE							
Beach Sand and Foredune Assoc.	Sandy	3,545	0-6'	Rapid	Rapid	Slight	Sea-Oats, Seashore Elder
SOILS, PROPERTIES AND DOMINANT VEGETATION, MARSH ZONE, SOUTHERN OUTER BANKS							
Bohicket	Clayey		0'	Slow	Slow	Moderate	Incapable of supporting vascular plants
Carteret	Sandy		0'	Slow	Slow	Moderate	Smooth Cordgrass
SOILS, PROPERTIES AND DOMINANT VEGETATION, NORTHERN OUTER BANKS							
Currituck	Organic to >18" then Sandy		0'	Slow	Slow	Moderate	Black Needlerush, Sawgrass, Cattails, Eastern Baccharis, Waxmyrtle, Black Willow
SOILS, PROPERTIES AND ASSOCIATED VEGETATION OF NORTHERN OUTER BANKS SCRUB ZONE							
Hobony	Organic to >48" then Sandy		0'	Slow	Slow	Moderate	Black Needlerush, Eastern Baccharis, Giant Cordgrass, Saltgrass, Saltmeadow Cordgrass, Cattails
Newhan and Newhan-Corollo Complex	Sandy	10,468	6'	Rapid	Rapid	Slight	American Beachgrass Bitter Panicgrass, Waxmyrtle, Northern Bayberry, Yaupon Holly, Flameleaf Sumac

TABLE 1. CONTINUED

Soils	Dominant Texture	Acres (Area)	Depth To Water Table	Infiltration	Permeability	Water Holding	Dominant Vegetation
Caroll	Sandy	9,185	1.5' to 3'	Rapid	Moderate	Slight	Saltmeadow Cordgrass, Bitter Panicum, Silverleaf Croton, Largeleaf Pennywort, Seaside Goldenrod, Waxmyrtle, Yaupon Holly, Northern Bayberry, Eastern Baccharis, Live Oak, Loblolly Pine, Blueberry, Wild Olive, Seacoast Bluestem, Seashore Elder, Sea Rocket
Duckston	Sandy	11,017	0 to 3'	Slow (seasonally)	Slow (seasonally)	Slight	Saltmeadow Cordgrass, Waxmyrtle, Greenbrier, Eastern Baccharis, Black Willow, Red Bay, Cattail, Blueberry, Virginia Creeper
SOILS, PROPERTIES AND ASSOCIATED VEGETATION, NORTHERN OUTER BANKS FOREST ZONE							
Fripp	Sandy	6,187	6	Rapid	Rapid	Slight	Loblolly Pine, Live Oak, American Beech, Cherrybark Oak, Hickory, Flowering Dogwood, American Holly, Cabbage Palmetto, Devilwood, Yaupon Holly, Black Cherry, Eastern Red Cedar, Blackgun
SOILS, PROPERTIES AND ASSOCIATED VEGETATION, SOUTHERN OUTER BANKS FOREST ZONE							
Fripp	Sandy	106	6'	Rapid	Rapid	Slight	Loblolly Pine, Live Oak, Cherrybark Oak, Hickory, Flowering Dogwood, American Holly, Cabbage Palmetto, Devilwood, Yaupon Holly, Black Cherry Eastern Red Cedar, Blackgum
SOILS, PROPERTIES AND DOMINANT VEGETATION OF SOUTHERN OUTTER BANKS SCRUB ZONE							
Newhan	Sandy	9,556	6'	Rapid	Rapid	Slight	Yaupon Holly, Eastern Red Cedar, Waxmyrtle, Eastern Baccharis
Corolla	Sandy	2,252	2' to 5'	Rapid	Rapid	Slight	Saltmeadow Cordgrass, Bitter Panicum, Silver Leaf Croton, Live Oak, Loblolly Pine
Duckston	Sandy	3,470	9" to 2'	Rapid	rapid	Slight	Saltmeadow Cordgrass, Eastern Baccharis, Balck Willow, Red Bay, Breenbrier, Loblolly Pine, White Oak, Sweetgum

Appendix 3.3.3 Continued

Each figure indicates the relative depths and specific horizons of each soil along with the height of the seasonal high water table. In addition, soil depths for five on-site wastewater management technologies are shown on the left side of each soil profile:

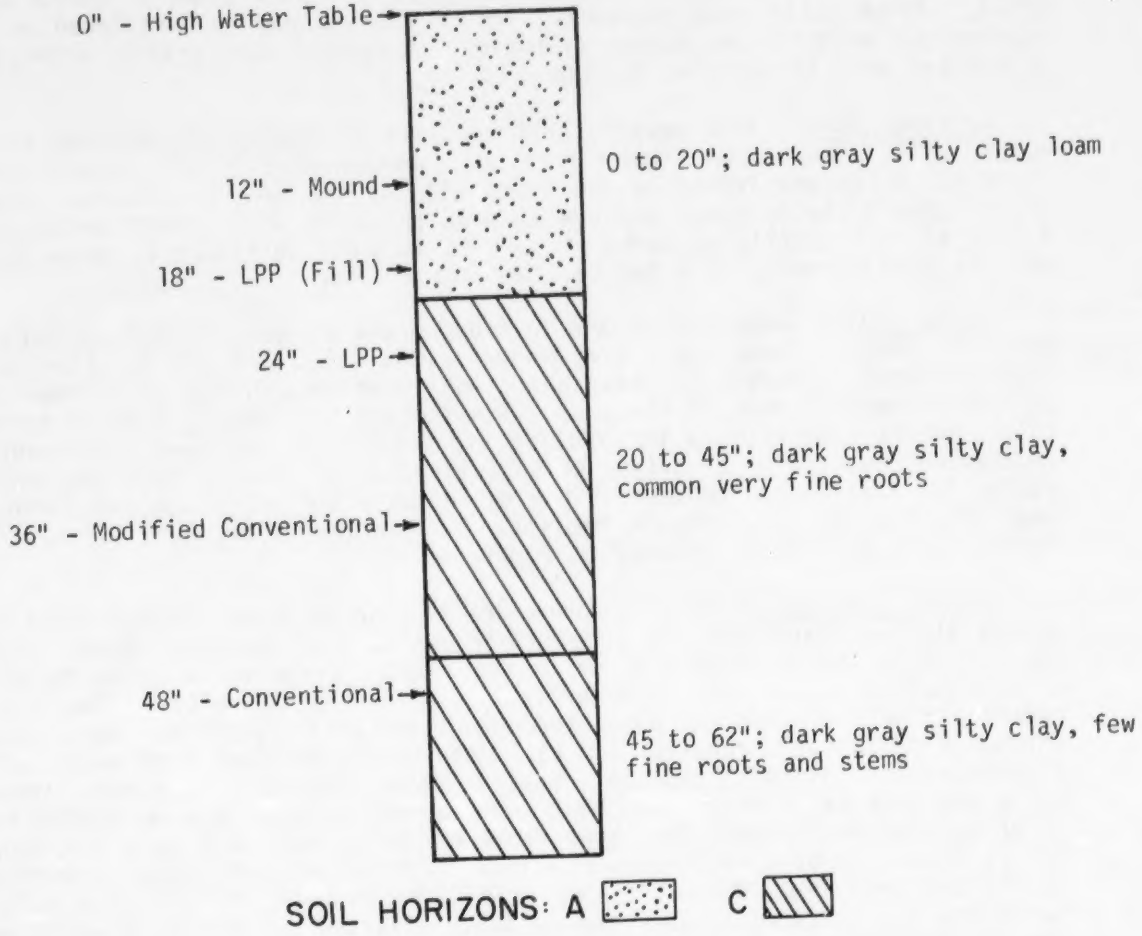
12" - mound
18" - low pressure piping with fill
24" - low pressure piping - no fill
36" - modified conventional ST/SA
48" - conventional ST/SA

The five technologies listed are appropriate for use when a restrictive horizon or high water table is found at the depth listed with each system and adequate land area is available for siting on-site soil absorption systems. For example, if a soil has a high water table at 12", the only technology that will function properly is the mound system. In contrast, if the restrictive horizon is below 48", then a conventional septic tank/soil absorption system will provide adequate wastewater treatment. Any of the other four technologies would also function properly with the restrictive horizon at this depth but since the costs are higher for those systems, the conventional system would probably be the system of choice. If a restrictive horizon is found above 12" such as in Bohicket (figure 1) soils where the seasonal high water table is at the ground's surface, then none of the five technologies will provide adequate wastewater treatment because the soil is saturated and will not renovate effluent applied to the soil. In this case, off-site wastewater disposal methods will have to be considered if the site is to be developed.

Beach Occasionally Flooded - This soil mapping unit occurs mainly on small islands and on the north side of inlets along the Outer Banks. In some areas that extend from the ocean through to the sound, the mapping unit is generally smooth and nearly level; but in some areas there may be small dunes present. The soil is sandy throughout and has shells and shell fragments located throughout the profile. These soils are covered daily by tidal flow and water table will range from 0 to 3 feet. This soil is well suited for beach recreational activities.

Beach Foredune Association - This mapping unit is located on the ocean side of the islands. It is generally long and narrow and includes the beach and the frontal dune. The foredune is frequently covered with vegetation which consists primarily of beach cresses, seaoats, coastal panicgrass, and bitter panic. Low lying areas are flooded daily by tidal action. The dune portion of this association ranges in height from 3 feet above sea level to a maximum of approximately 20 feet above sea level. In some cases the foredune is absent as it has been breeched by tidal wind or wave action. The foredune serves as protection for the leeward areas during storm events and in some areas foredunes have been artificially constructed to function as barriers between the island and the encroaching sea.

Bohicket Soils - This mapping unit consists of very poorly drained clayey marsh soils. These soils occur primarily in the southern part of the survey area where rivers and streams empty directly into the ocean. These soils



BOHICKET SOILS

0" - High Water Table
12" - Mound
18" - LPP (Fill)
24" - LPP
36" - Modified Conventional
48" - Conventional
0 to 20"; dark gray silty clay loam
20 to 45"; dark gray silty clay, common very fine roots
45 to 62"; dark gray silty clay, few fine roots and stems
SOIL HORIZONS: A ▨ C ▨

Figure 1

were formed in clayey sediments that were washed from drainage areas further inland. These soils are generally from one to three feet above mean sea level and are flooded frequently with sea water. They are continuously wet, soft, and mushy. Vegetative cover is essentially a pure stand of smooth cordgrass. These soils have extremely limited use and may be considered as a habitat for wildlife and marine fisheries. A typical soil profile drawing of a Bohicket soil is depicted in Figure 1.

Carteret Soil - This mapping unit consists of very poorly-drained sandy marsh soils. They occur primarily in the southern part of the coastal zone. Carteret soils are formed on the sound side of the barrier islands. They are flooded daily by tides and are covered primarily with smooth cordgrass. A typical soil profile of Carteret soil is attached as Figure 2. Again this soil is used primarily as a habitat for marine life.

Conaby Soil - Conaby soils are in troughs and depressions located between forested dunes. These areas are generally elongated and are parallel to forested dunes. These soils have a seasonal high water table at or near the surface throughout much of the year. The surface is commonly 8 to 16 inches thick and is underlain by decomposing organic matter and sand. Dominant vegetation consists of a variety of vascular plants. Conaby soils are poorly suited for development because of the water table and organic matter content. They are, however, significant habitats for certain animals and birds. A typical soil profile is included as Figure 3.

Corolla Fine Sand - Corolla sands are located on broad, nearly level to gently sloping flats that lie immediately behind the foredune. These flats may extend to the forested area or to the sound. These soils typically have a thin surface layer that is exceedingly low in organic matter. They are moderately well drained and sandy throughout the entire profile. Water moves through Corolla soils readily, but the depth to the seasonal high water table fluctuates with seasonal changes. During wetter seasons of the year, these soils may have water within 1.5 to 2 feet of the surface, whereas during the drier seasons of the year the water table may be as much as 6 to 8 feet below the surface. Corolla soils may be either forested or nonforested depending on the distance from the salt spray. Those soils being further from salt spray are the forested soils, whereas those affected by salt spray would be the nonforested soils. Major plant species are listed in Table 1 and a typical soil profile is attached as Figure 4.

Corolla Duckston Complex - This mapping unit occurs on nearly level to slightly depressed areas that lie immediately inland from the frontal dune. Corolla soils are generally dominant and Corolla soils of this mapping unit are similar to those described for Corolla fine sands. During wet periods, the water table is within 1.5 to 3 feet of the surface, being deeper during drier periods. Natural vegetation is varied on this soil. The Duckston soils are in the wetter, slightly lower depressional areas. Their characteristics are similar to those given in the Duckston fine sand mapping unit discussed later. Seasonal high water table is at or near the surface of the soil during wet periods of the year and falls during the drier periods of the year. Native vegetation is varied and is listed in Table 1. A development on this mapping unit is less desirable than that for areas of Duckston fine sands.

CARTERET SOILS

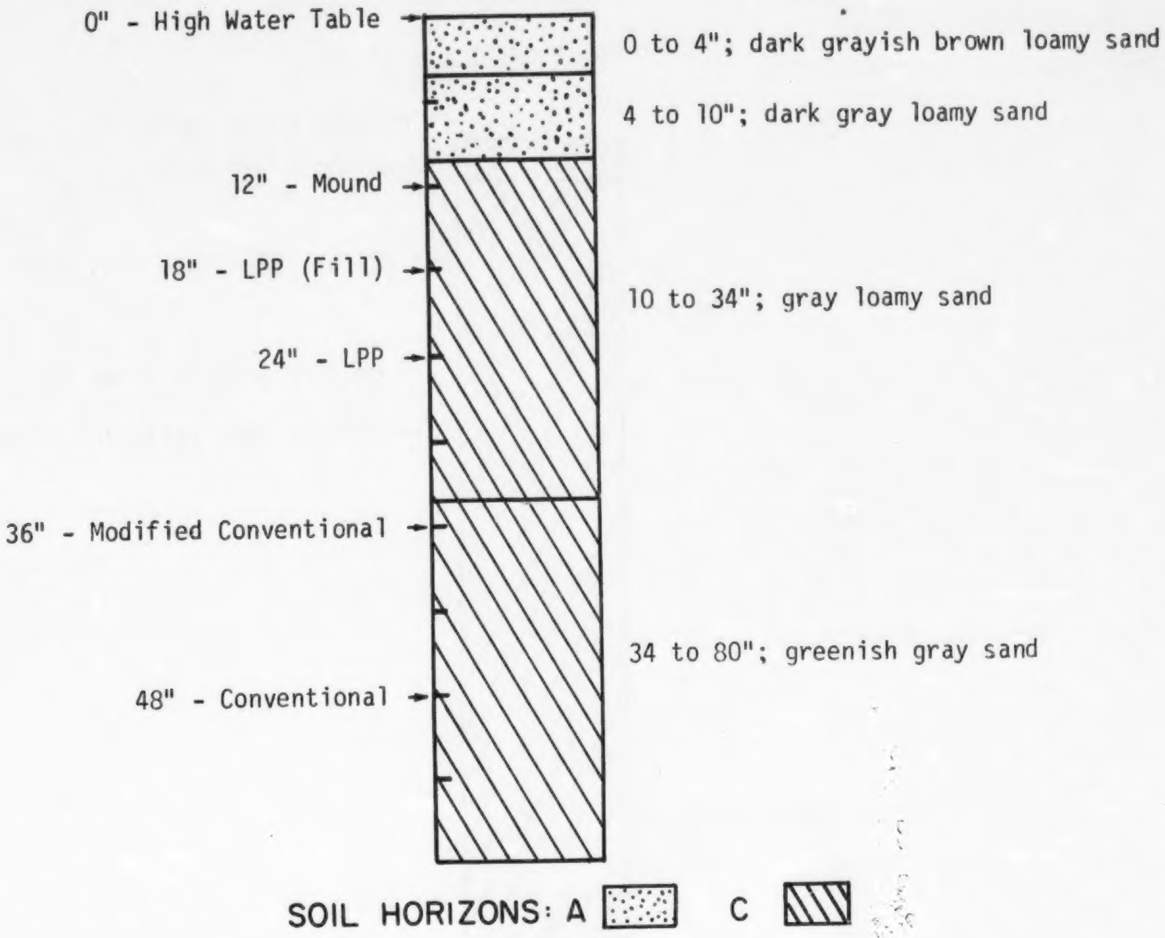
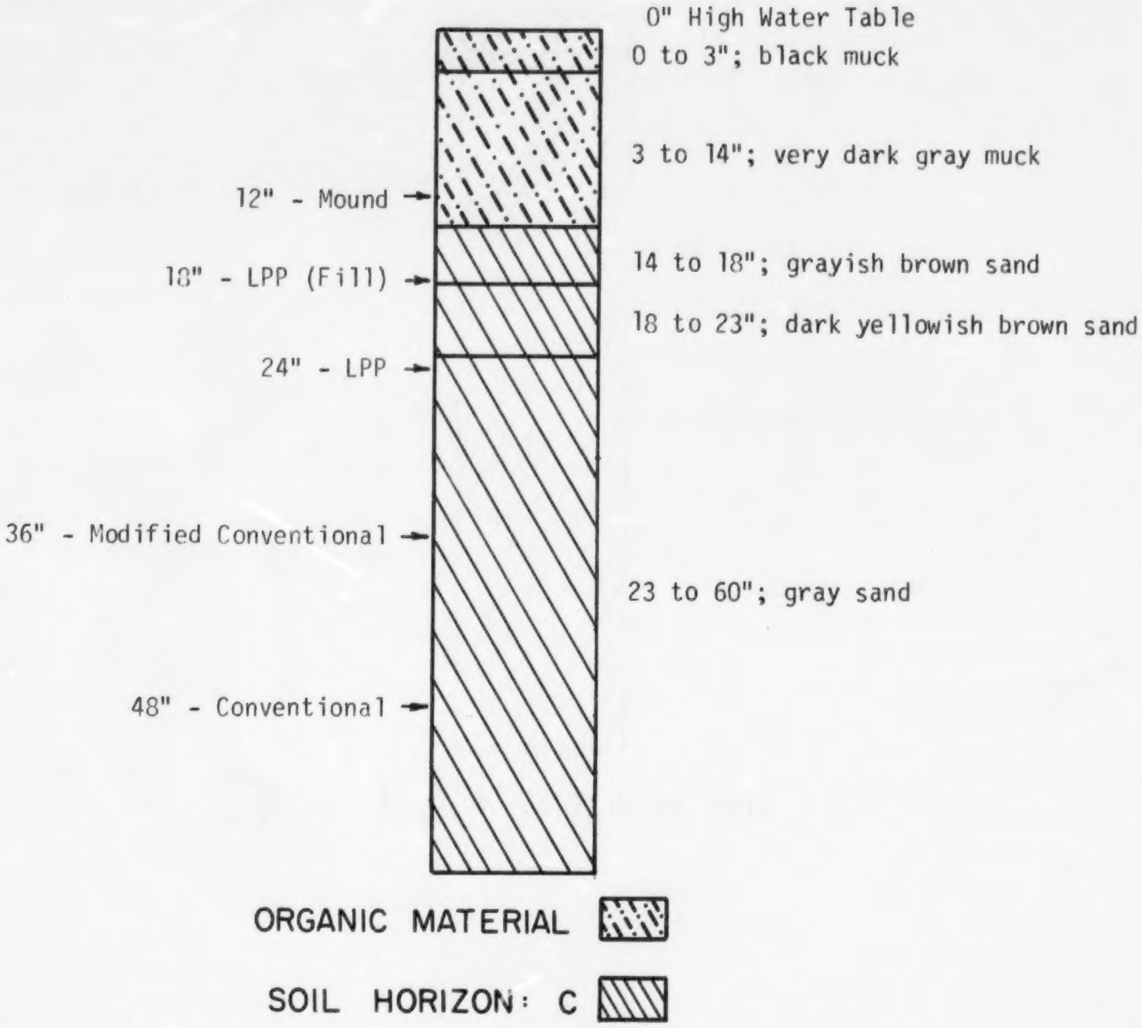

0" - High Water Table
0 to 4"; dark grayish brown loamy sand
4 to 10"; dark gray loamy sand
12" - Mound
18" - LPP (Fill)
10 to 34"; gray loamy sand
24" - LPP
36" - Modified Conventional
34 to 80"; greenish gray sand
48" - Conventional
SOIL HORIZONS: A
C

Figure 2



CONABY SOILS

0" High Water Table
0 to 3"; black muck
3 to 14"; very dark gray muck
12" - Mound
14 to 18"; grayish brown sand
18" - LPP (Fill)
18 to 23"; dark yellowish brown sand
24" - LPP
36" - Modified Conventional
23 to 60"; gray sand
48" - Conventional
ORGANIC MATERIAL
SOIL HORIZON: C

Figure 3

CORELLA FINE SAND

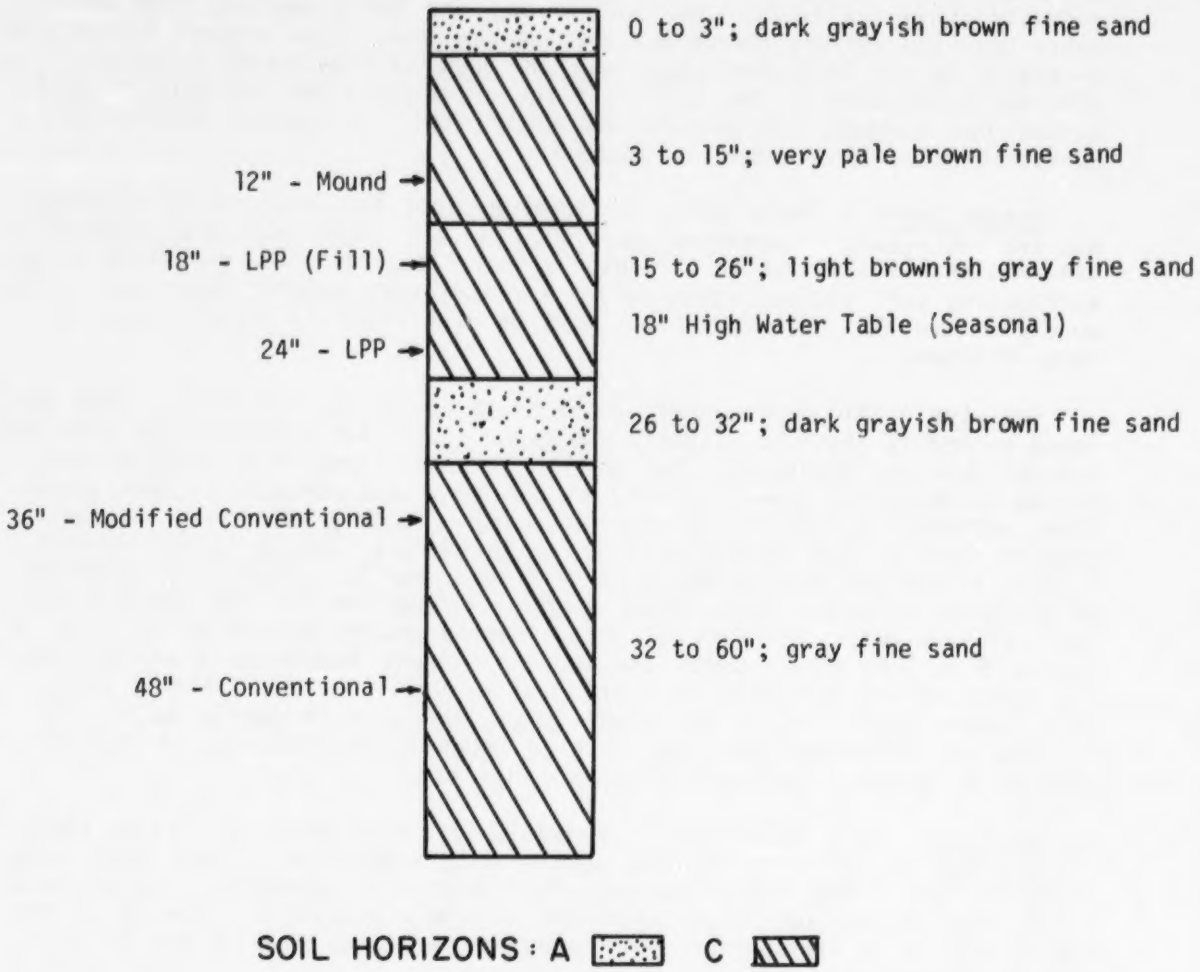

0 to 3"; dark grayish brown fine sand
3 to 15"; very pale brown fine sand
12" - Mound
18" - LPP (Fill)
15 to 26"; light brownish gray fine sand
18" High Water Table (Seasonal)
24" - LPP
26 to 32"; dark grayish brown fine sand
36" - Modified Conventional
32 to 60"; gray fine sand
48" - Conventional
SOIL HORIZONS: A
C

Figure 4

Appendix 3.3.3 Continued

Currituck Soils - This mapping unit consists of shallow organic marsh soils. They are located primarily in two areas in Dare County. These soils occur on the inland side of the barrier island and elevations are at or slightly above sea level. The soil is wet and has a seasonal high water table near the surface throughout most of the year. The organic layers are typically 18 to 36 inches thick and are underlain by sandy materials. Dominant vegetation on the soil is black needlegrass and the soil is well suited for habitats for animals and water fowl. A typical profile of Currituck soils is depicted in Figure 5.

Dredge Soils - These soils are located along the intercoastal waterway and are the result of dredging activities by man. Most areas are composed of sand and shells and have an irregular shape. They have been deposited on the surrounding soil surface which is for the most part marsh. These soils are poorly suited for development and must be stabilized to prevent wind and water erosion.

Duckston - This mapping unit consists of poorly-drained soils. They are found on nearly level to slightly depressed flats that extend inland from the frontal dune to the marsh. The profile is sandy throughout. Native vegetation is dependent upon proximity to the ocean and exposure to salt spray. Areas affected by salt spray are vegetated primarily with salt tolerant grasses such as salt medicored grass or waxmyrtle, whereas areas located further inland and less affected by salt spray may be inhabited by a variety of different plants. Water moves readily through the soil and depth of the seasonal high water table is variable. During wetter seasons of the year it may be from 2 to 5 feet below the surface. Areas located well inland from the ocean may be dominated by plant species which include loblolly pines, oats, sweet gums, maples, and black gums. The area is poorly suited for residential development because of high water table problems. A typical profile of Duckston sand is included as Figure 6.

Duneland - This mapping unit is made up of large areas of flowing sands. The surface is poorly or sparsely populated by vegetation. These dunes range in height from a few feet to several hundred feet in elevation. Water table is at great depths and these soils are extremely droughty. These soils are poorly suited to residential development because they are located in protected national park areas.

Echaw Fine Sand - These soils are located on nearly level to gently sloping areas on barrier islands. They are sandy throughout and may have a seasonal high water table at about 5 feet. Soils may have a weakly cemented hard pan at a depth of 30 inches. This may cause water to perch above the layer for short periods of time following heavy rains, however, water moves through the soil profile readily. Native vegetation is loblolly pine, live oak, waxmyrtle and greenbriar. The vegetation is often sculptured by salt spray and assumes a variety of interesting forms. The soil is well suited for development and a typical soil profile is included as Figure 7.

Fripp Fine Sand - Fripp sands are well-drained to excessively well-drained soils that formed on sandy ridges and on side slopes along

CURRITUCK SOILS

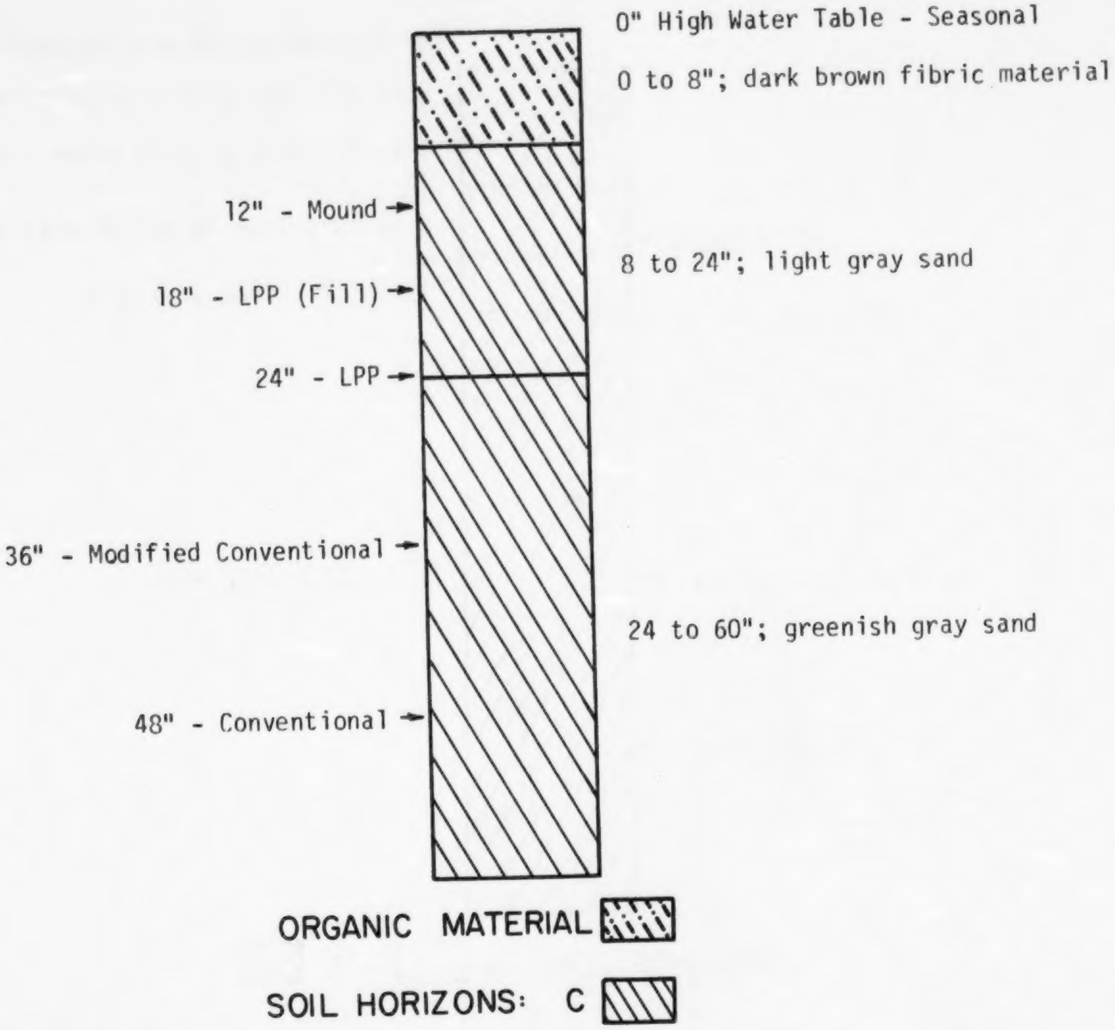

0" High Water Table - Seasonal
0 to 8"; dark brown fibric material
12" - Mound
18" - LPP (Fill)
24" - LPP
8 to 24"; light gray sand
36" - Modified Conventional
24 to 60"; greenish gray sand
48" - Conventional
ORGANIC MATERIAL ▨
SOIL HORIZONS: C ▧

Figure 5

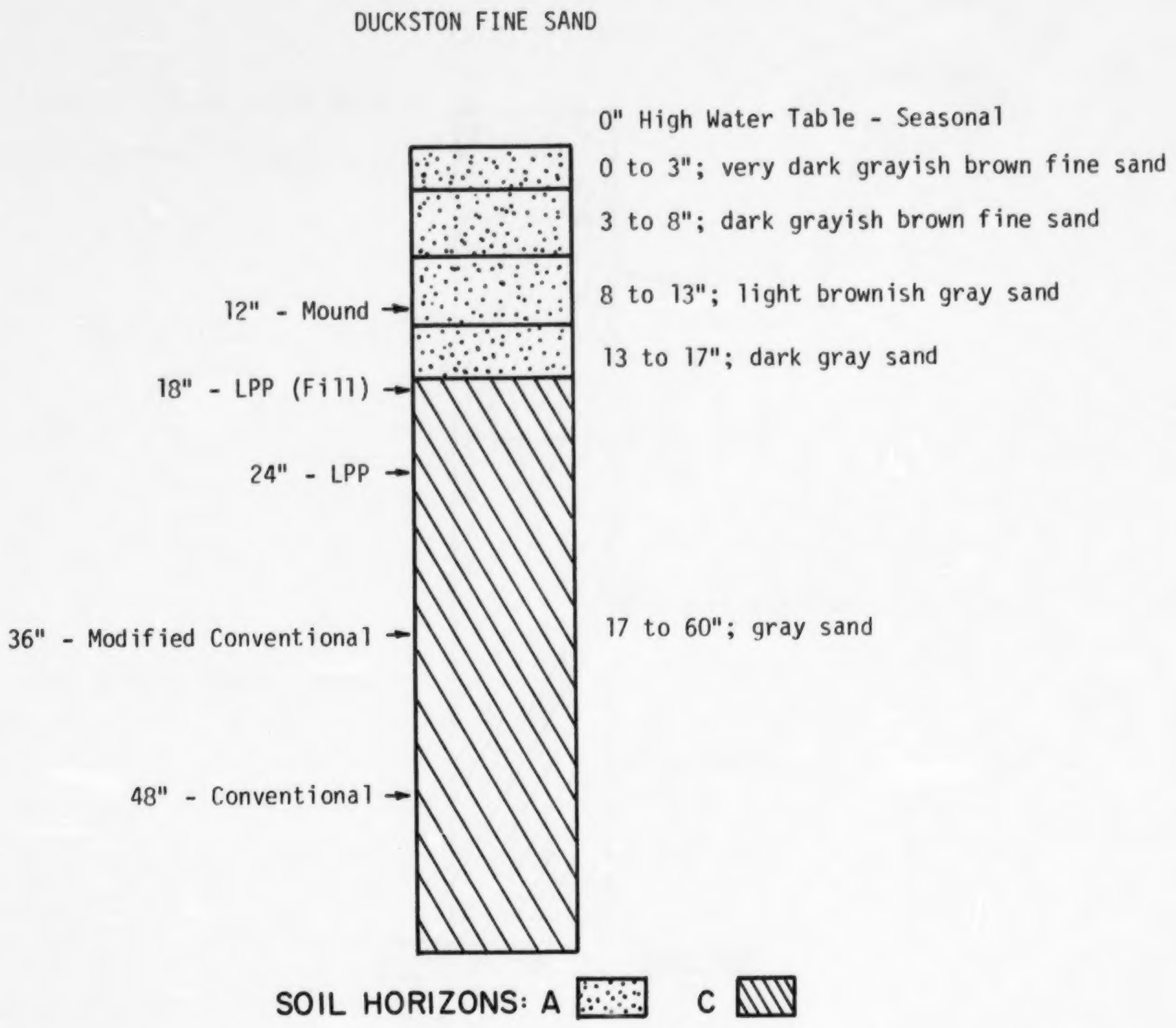

DUCKSTON FINE SAND
0" High Water Table - Seasonal
0 to 3"; very dark grayish brown fine sand
3 to 8"; dark grayish brown fine sand
8 to 13"; light brownish gray sand
13 to 17"; dark gray sand
17 to 60"; gray sand
12" - Mound
18" - LPP (Fill)
24" - LPP
36" - Modified Conventional
48" - Conventional
SOIL HORIZONS: A
C

Figure 6

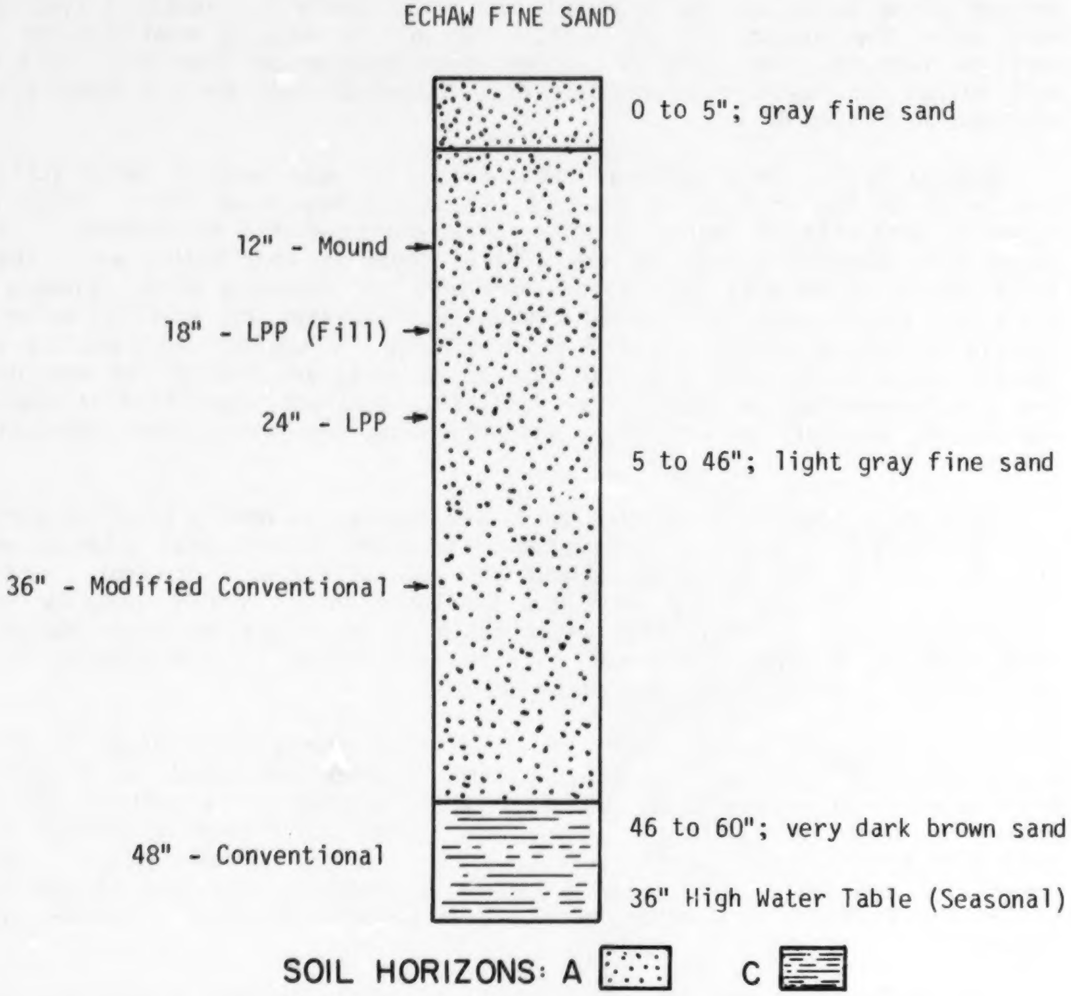

ECHAW FINE SAND
0 to 5"; gray fine sand
12" - Mound
18" - LPP (Fill)
24" - LPP
5 to 46"; light gray fine sand
36" - Modified Conventional
46 to 60"; very dark brown sand
48" - Conventional
36" High Water Table (Seasonal)
SOIL HORIZONS: A
C

Figure 7

portions of the sound side of the barrier islands. Water is readily moved through Fripp soils and the seasonal high water table is usually 5 feet or more below the surface of the soil. The soil is usually dominated by maritime forests. Tree species include loblolly pine and live oak. Soil is well suited for residential development. A typical soil profile drawing is included as Figure 8.

Hobonny Soil - This mapping unit consists of deep organic marsh soils that occur in the vicinity of Roanoke Island and Nags Head woods. Organic layer is generally 48 inches or more thick and is highly decomposed. The sandy soil material underlying the organic layer is continually wet. The soils appear to be soft and viscous and they are commonly at or slightly above sea level. Soil is flushed with both freshwater and brackish water, especially during periods of wind and high tide. A typical soil profile of Hobonny soils is included as Figure 9. These soils are limited for most uses and are recommended as habitat for wildlife. Dominant vegetation is black needlerush; however, in some areas slightly above sea level, other vegetation may occur.

Kureb Fine Sands - Kureb fine sands are located in nearly level to gently sloping areas that occur on peninsulas between the intercoastal waterway and the dunes. They are sandy throughout and excessively well drained. Water moves rapidly through these soils and available water holding capacity is exceedingly low. Seasonal high water table is 60 inches or lower. Native vegetation is oak and pine. The soil is well suited to development. A typical soil profile is incuded as Figure 10.

Leon Fine Sands - Leon sands are located on nearly level areas in the southern part of the survey area. Profile is sandy throughout and seasonal high water is at or near the surface. Native vegetation is loblolly pine, waxmyrtle, live oak, holly and greenbriar. Water moves readily through the soil during dry periods of the year, but it is at the surface during wetter periods of the year. Because of water table problems, the soil is poorly suited for residential development. A typical soil profile is included as Figure 11.

Levy Soil - This mapping unit consists of poorly-drained mineral soils on isolated islands in Currituck Sound. The soils are formed in clayey marine sediments. They are continuously saturated and footing is unstable. Water surrounding the islands is generally fresh or brackish. Soils occur at elevations from sea level to slightly more than one foot above sea level. They are continuously flooded and poorly suited for residential development. Native vegetation includes cordgrass, needlerush, salt grass and few other weeds and grasses. These soils are limtied for purposes other than wildlife and marine habitats. A typical soil profile drawing is included as Figure 12.

Madelands - This mapping unit is adjacent to the water on the sound side of the barrier islands. The soil material has been pumped or dredged during construction of finger canals and has been deposited between the canals to be used as building sites. The average thickness of the soil material ranges from 3 to 6 feet and water table fluctuates with changes in tide. Most fre-

FRIPP FINE SAND

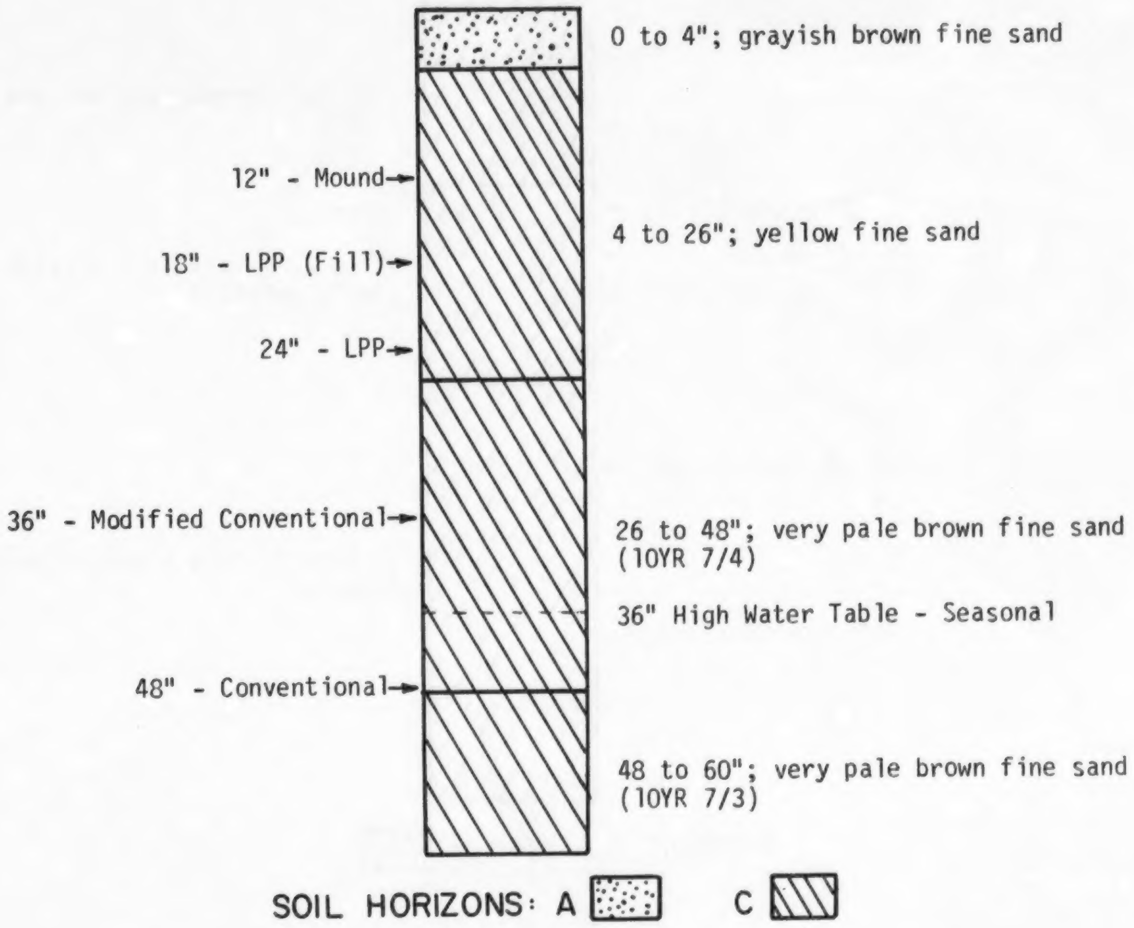

0 to 4"; grayish brown fine sand
12" - Mound
18" - LPP (Fill)
4 to 26"; yellow fine sand
24" - LPP
36" - Modified Conventional
26 to 48"; very pale brown fine sand (10YR 7/4)
36" High Water Table - Seasonal
48" - Conventional
48 to 60"; very pale brown fine sand (10YR 7/3)
SOIL HORIZONS: A C

Figure 8

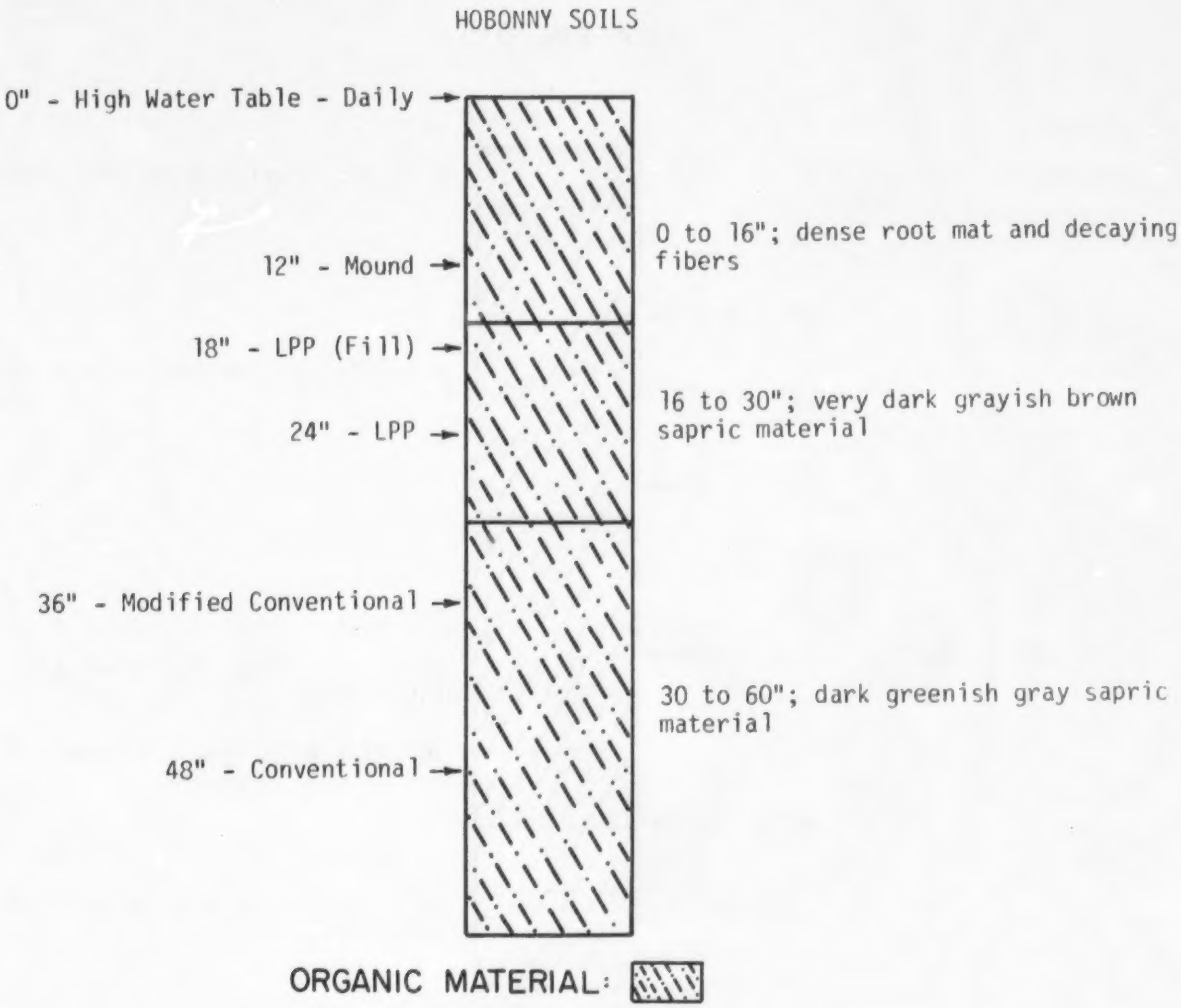

HOBONNY SOILS
0" - High Water Table - Daily
12" - Mound
18" - LPP (Fill)
24" - LPP
36" - Modified Conventional
48" - Conventional
0 to 16"; dense root mat and decaying fibers
16 to 30"; very dark grayish brown sapric material
30 to 60"; dark greenish gray sapric material
ORGANIC MATERIAL: ▨

Figure 9

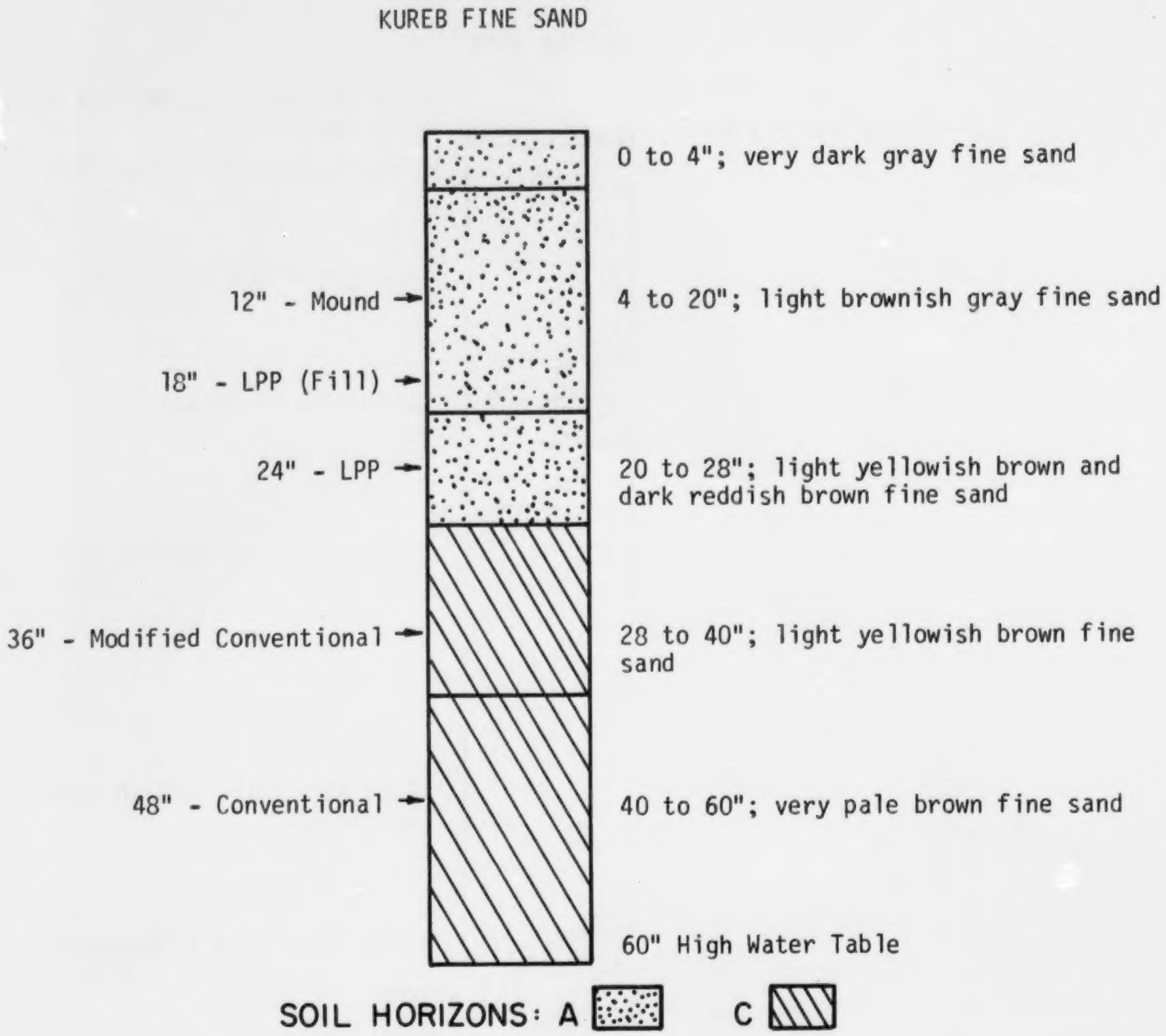

KUREB FINE SAND
0 to 4"; very dark gray fine sand
12" - Mound
4 to 20"; light brownish gray fine sand
18" - LPP (Fill)
24" - LPP
20 to 28"; light yellowish brown and dark reddish brown fine sand
36" - Modified Conventional
28 to 40"; light yellowish brown fine sand
48" - Conventional
40 to 60"; very pale brown fine sand
60" High Water Table
SOIL HORIZONS: A
C

Figure 10

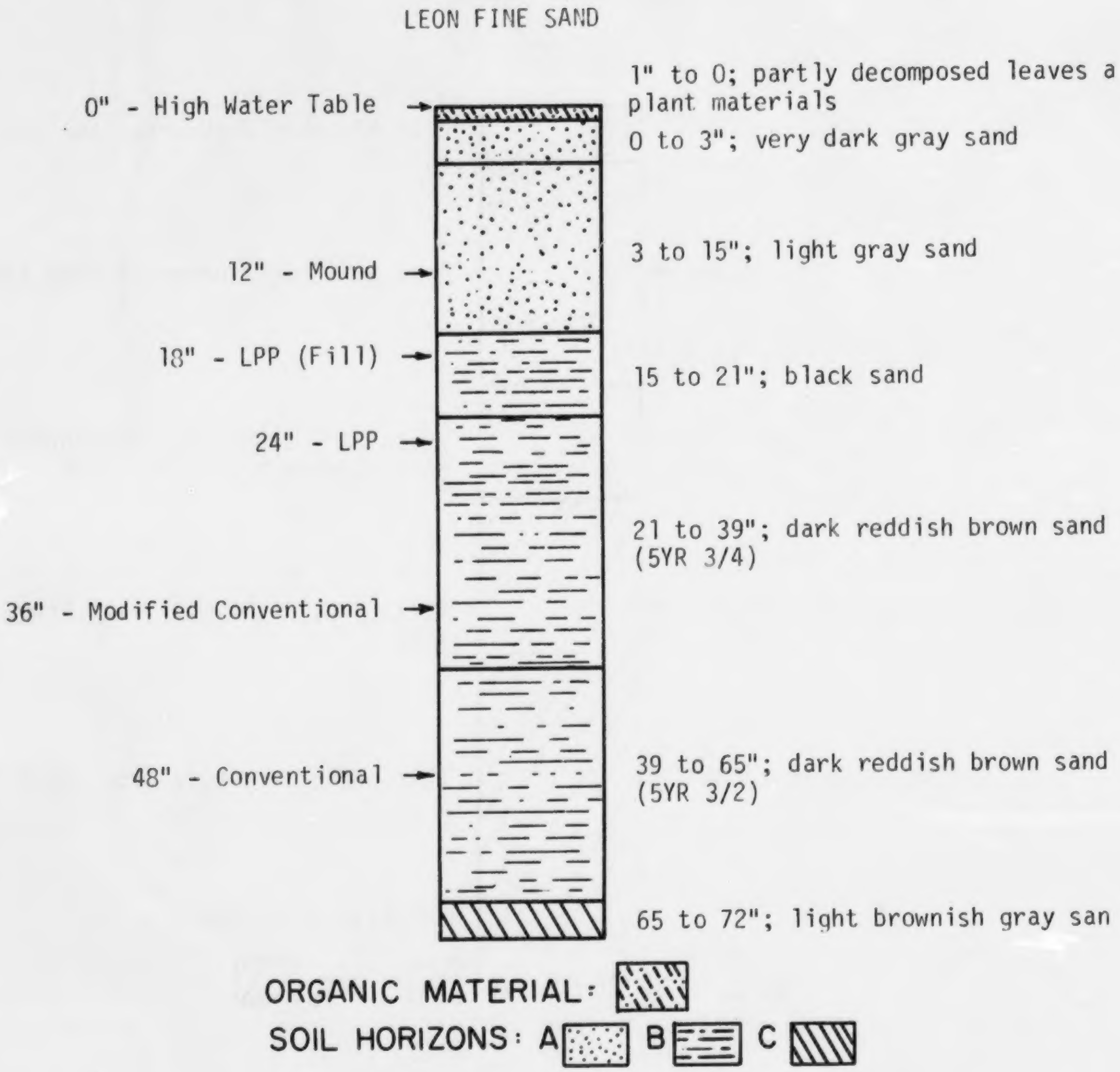

LEON FINE SAND
0" - High Water Table
12" - Mound
18" - LPP (Fill)
24" - LPP
36" - Modified Conventional
48" - Conventional
1" to 0; partly decomposed leaves a plant materials
0 to 3"; very dark gray sand
3 to 15"; light gray sand
15 to 21"; black sand
21 to 39"; dark reddish brown sand (5YR 3/4)
39 to 65"; dark reddish brown sand (5YR 3/2)
65 to 72"; light brownish gray san
ORGANIC MATERIAL:
SOIL HORIZONS: A B C

Figure 11

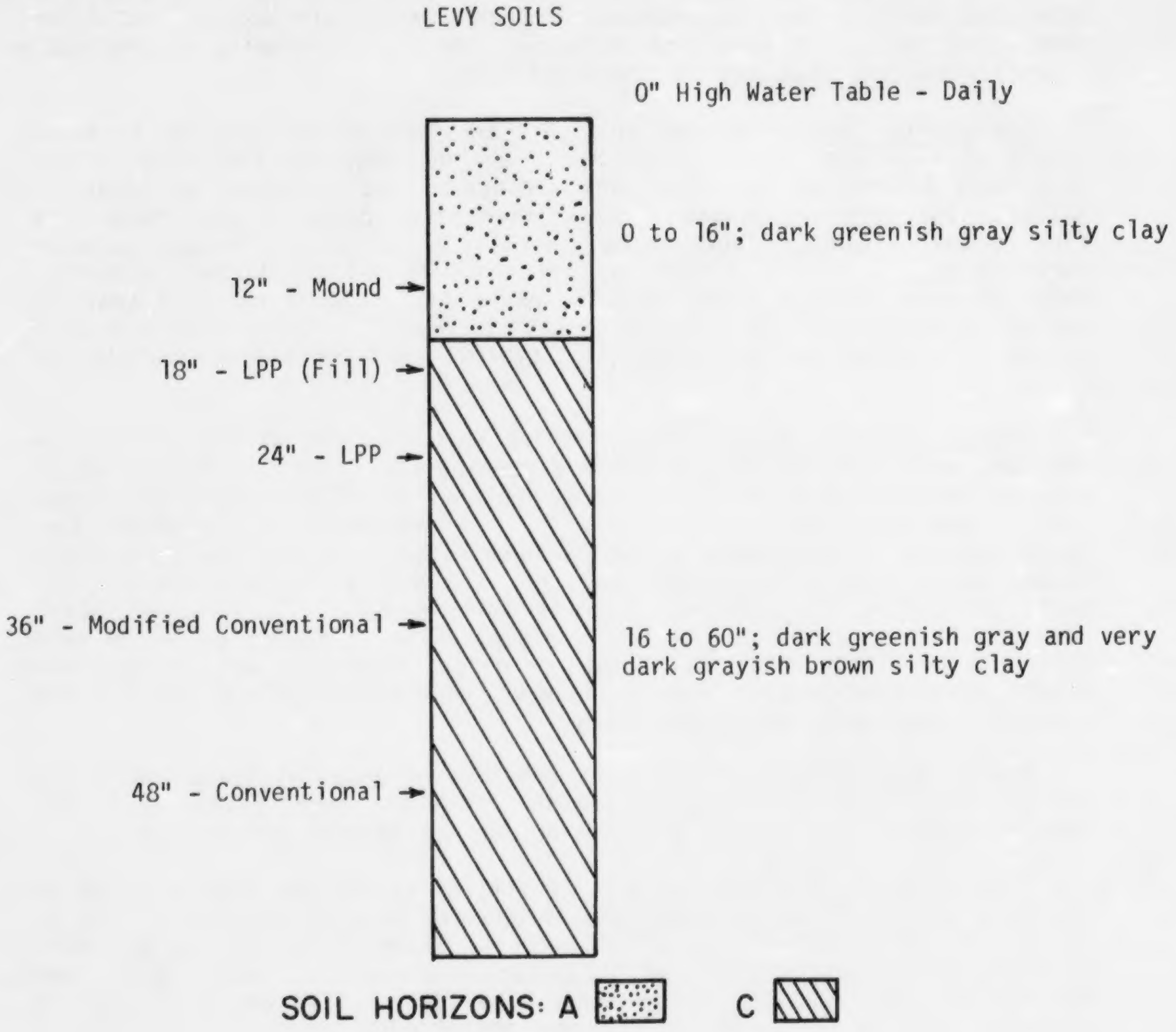

LEVY SOILS
0" High Water Table - Daily
0 to 16"; dark greenish gray silty clay
12" - Mound
18" - LPP (Fill)
24" - LPP
36" - Modified Conventional
16 to 60"; dark greenish gray and very dark grayish brown silty clay
48" - Conventional
SOIL HORIZONS: A ▒ C ▨

Figure 12

quently water level is at a depth of 2 to 4 feet below the surface. Water moves readily through the material in most areas. These soils generally have poor filtering capacity for effluents and there is potential hazard of ground water and surface water contamination. These areas are commonly used for home sites because of access to the water. No profile drawing is provided as a profile has not developed in these soils.

Newhan Fine Sand - This mapping unit consists of well-drained to excessively well-drained soils. These soils are droughty and fertility is low. They have a thin surface layer which contains small amounts of organic matter. The soil has formed in stratified sandy deposits that range from fine to coarse sands. These soils generally occur in long ridges on dunes parallel to the ocean. Elevations may range from 5 to 60 feet or more. Water movement through these soils is rapid and areas of the soil that are devoid of vegetation are subject to severe blowing. These soils are well suited to residential development. A typical soil profile is included as Figure 13.

Newhan-Corolla Complex - This mapping unit consists of two soils. The dominant being the Newhan and the minor being the Corolla. They occur in such an intricate pattern on the landscape that it is unfeasible to separate them at the scale used in soil mapping. The Newhan soils are on the low dunes and are well-drained, while the Corolla soils occupy the irregularly shaped basin between the dunes, and they are moderately well drained and sandy throughout the profile. Corolla soils typically have water table within 15 to 18 inches of the soil surface, while in Newhan soils the water table may be 7 feet below the surface or more. Soils that are not covered by vegetation are subject to blowing. Common vegetation includes beach grass, waxmyrtle, bayberry, and yaupon holly.

Newhan Urban Complex - This unit consists of areas of Newhan soils that are currently developed with residences. They are found primarily in the Nags Head area. The soil is well suited for residential development.

Tidal Flats - This mapping unit is similar to the mud flat areas on the southern end of Ocracoke Island and throughout much of Core Banks. It is devoid of vegetation and sandy throughout. Tidal flats receive periodic overwash from tides, and salt accumulation in the soil is high. Water moves through the soil readily, but seasonal high water tables are at or near the surface. Soil is poorly suited for residential purposes.

Wando Fine Sands - Wando soils are located in the southern portion of the Outer Banks. They are located on the high ridges and flats on the sound side of the barrier islands. Often they are located far inland and do not receive any salt sprays. The soils are sandy throughout and excessively well drained. Water table is located at a depth of 5 feet or more. Infiltration and permeability of the soil is high. Native vegetation is loblolly pine, live oak, American holly, dogwood, and hickory. The soil is well suited for residential development and presents no problems for the operation of on-site wastewater treatment systems if they are installed properly. A typical soil profile is included as Figure 14.

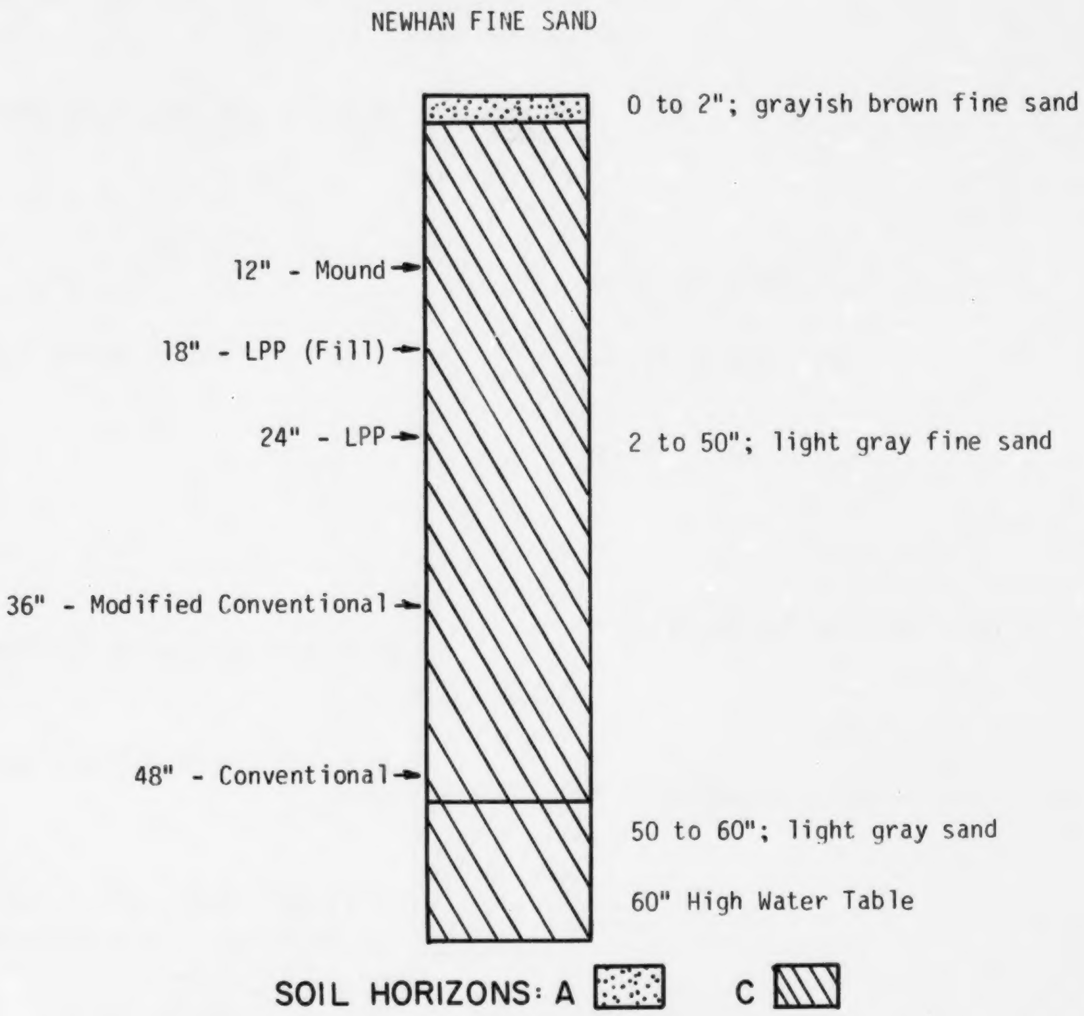

NEWHAN FINE SAND
0 to 2"; grayish brown fine sand
12" - Mound
18" - LPP (Fill)
24" - LPP
2 to 50"; light gray fine sand
36" - Modified Conventional
48" - Conventional
50 to 60"; light gray sand
60" High Water Table
SOIL HORIZONS: A ▨ C ▨

Figure 13

WANDO FINE SAND

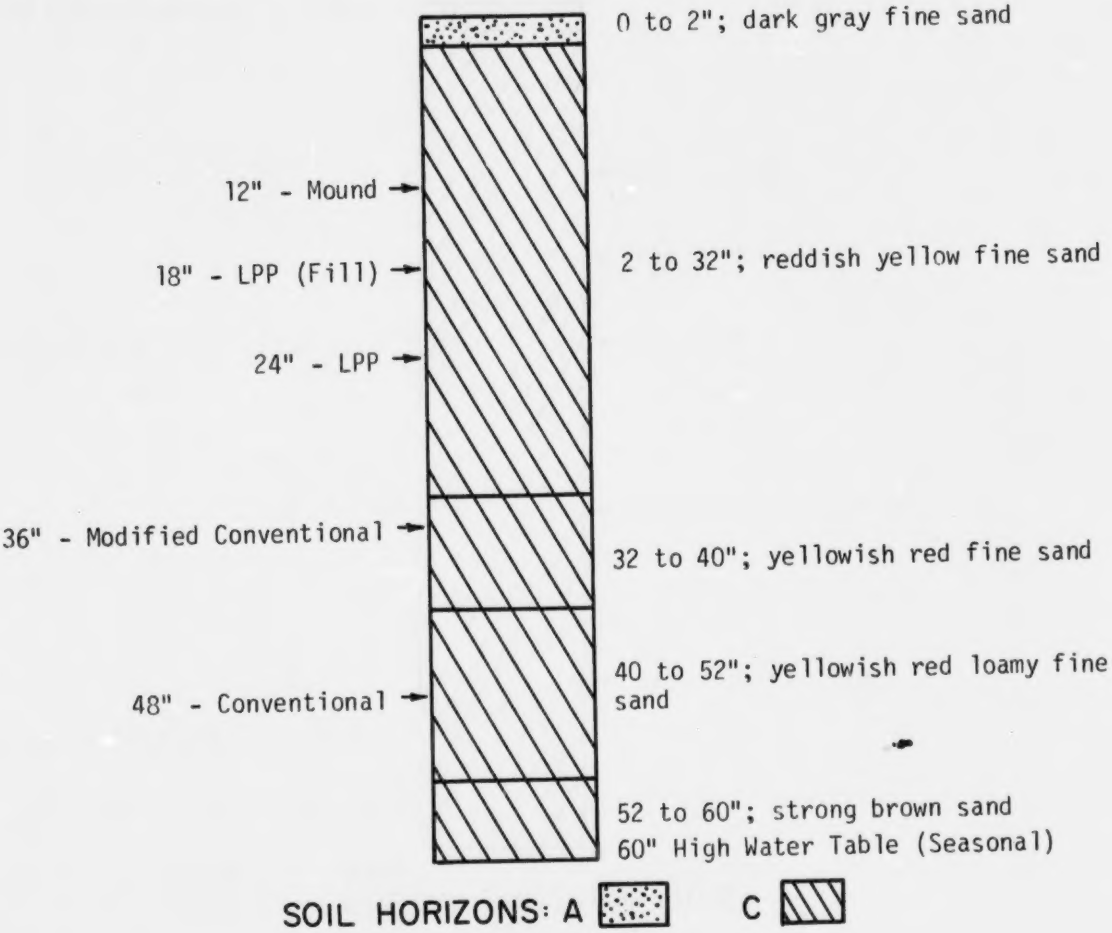

0 to 2"; dark gray fine sand
12" - Mound
18" - LPP (Fill)
2 to 32"; reddish yellow fine sand
24" - LPP
36" - Modified Conventional
32 to 40"; yellowish red fine sand
40 to 52"; yellowish red loamy fine sand
48" - Conventional
52 to 60"; strong brown sand
60" High Water Table (Seasonal)
SOIL HORIZONS: A
C

Figure 14

Appendix 3.3.3 Continued

Guidelines for Siting

The purpose of this section of the report is to provide the criteria and guidelines for siting on-site wastewater treatment systems in the Outer Banks of North Carolina. This section of the report draws upon several years of experience with these systems under conditions similar to those experienced in the Outer Banks. The principal investigator for most of this work was B. L. Carlile, Ph.D., North Carolina State University, Soil Science Department, and his colleagues. This portion of the report is not intended to be a comprehensive manual for siting and providing criteria for all soils and site conditions where alternatives could possibly be used. It is intended to provide general siting and guidance criteria.

Laws and rules for ground absorption sewage disposal systems have been interpreted by the North Carolina Department of Human Resources and a set of guidelines exists for determining the suitability of a site for ground absorption of effluent. A variety of site and soil factors are evaluated; based upon these factors, a given piece of property is determined to be suitable, provisionally suitable, or unsuitable for ground absorption sewage disposal systems. The criteria for determining suitability of a site include:

1. topography
2. soil texture
3. soil structure
4. soil depth
5. restrictive horizons (peat layers, seasonal high water table)
6. soil drainage
7. estimated percolation
8. available space

Several alternative systems have been developed which will overcome some of the limitations imposed on a soil body by soil or site properties. These systems include both modifications of conventional septic system practice and alternatives to conventional septic system practice.

The performance of conventional on-site systems may be satisfactory in many areas on the Coastal Plain. Areas where minor modifications to conventional systems may be desirable would include areas with seasonally high water table depth of approximately 24 inches or more. A modification to the conventional septic tank (i.e., a two compartment tank) is recommended throughout all installations in North Carolina.

A two compartment septic tank is an improved version of a standard septic tank. It does enhance solids separation through the use of a slotted baffle wall or partition inside the tank. Ideally the partition is installed at the factory, but it may be installed on the site. It is recommended that this partition be installed between two-thirds and three-fourths of the distance from the inlet of the tank. This baffle has a slit which will allow clarified liquid to flow into the second compartment where additional settling may occur. Settleable solids and floating scum are retained much more efficiently in this system than in a single compartment tank.

A second modification is a V-ditch modification. The V-ditch is a conventional septic tank soil absorption system with a V-shaped rather than a conventional rectangular trench. The purpose of this V-modification is to maximize the ratio of trench sidewall to bottom area and to minimize depth requirements. The V-ditch takes advantage of the fact that effluent infiltrates through sidewalls of the trench rather than through trench bottoms. An additional advantage is that the sidewall can be raked and limed much more easily with the V-modification than with the conventional rectangular modification. Another advantage is that the V-modification is less expensive than conventional rectangular trenches because smaller quantities of gravel must be placed in the trench. It may be installed in areas where soil depth is 24 inches or greater.

A third modification that may be considered is the replacement of highly permeable trench field material with material that is less permeable but has more absorptive sites for effluent treatment. In this system, the highly permeable material is excavated and replaced by the less permeable soils. A sandy loam topsoil would be ideal for this type of application as it would provide many reactive sites for effluent treatment. This type of system would require a natural soil depth of approximately 18 to 24 inches and would rely on either conventional gravity distribution or pressure distribution through the trenches.

Alternative On-Site Systems

Conventional septic tanks consist of a concrete or masonry tank where solids removal and decomposition result in a drain field in which the soil absorbs and treats effluent. Many areas of the coastal zone are not suited for conventional absorption systems due to one of the following conditions:

1. poor drainage
2. impermeable soils
3. high ground water
4. highly permeable soils

The following section summarizes several of the alternatives to conventional on-site systems which may overcome these soils or site limitations. In each alternative the goal is to maximize the sewage treatment capability of a given soil. It is clear that emphasis is placed on providing even distribution of effluent into the soils system. The alternatives listed have been evaluated experimentally at individual homes throughout the coastal zone of North Carolina and, when properly sited, sized, designed, installed, and maintained, will result in no discharge of effluents to surface waters.

Mound System - A mound or septic renovation levy (SRL) is an artificial fill system designed for on-site wastewater treatment and disposal. Waste is pumped into the top of the mound in controlled doses through small diameter perforated pipe. This will insure uniform distribution of effluent into the suitable fill material. Wastewater then moves by gravity through the fill which consists of a mix of topsoil and filter sand. Treatment is achieved by the physical, chemical and biological activity that occurs in the mound. Ultimate disposal of the effluent is achieved by a combination of vertical movement of the effluent into the underlying soil and lateral movement of the effluent both through the mound and over the underlying soil material. Additionally, some effluent is lost through evapotranspiration to the atmosphere.

Mounds can be used to overcome severe site or soil limitations due to shallow soils or high ground water. A minimum depth of 12 inches of suitable soils above a restrictive horizon or high ground water is required for the proper operation of a mound system.

Low Pressure Pipe System - A low pressure pipe system relies on pressure distribution of effluent into a soils system. Effluent is pumped under low pressure (between 2 and 5 psi) through a series of manifolds and laterals. Generally, these manifolds and lateral lines are small diameter PVC pipe placed at shallow depths in narrow trenches in the soil. Ideally the depth of the lateral distribution line is 12 to 15 inches. Since effluent treatment will occur in most soils in 12 inches of soil or less, a minimum soils depth of 24 inches above a restrictive horizon is required for the satisfactory operation of a low pressure pipe wastewater treatment system. A maximum of 6 inches of soil may be added to a soil horizon to yield the 24-inch separation between soil surface and restrictive horizon or water table. In the low pressure pipe wastewater treatment system, effluent is pumped from a pump tank to effluent distribution laterals in controlled doses. This insures uniform distribution of effluent throughout the entire absorption field and provides the most effective utilization of the area. In general, the low presure pipe system is well suited to soils and site limited situations that are somewhat less severe though similar to those that require a mound. These limitations include characteristics such as excessively permeable soils, high water table, or impermeable soils.

Alternatives Analysis

Modified conventional systems and alternative on-site wastewater treatment systems are not a panacea for wastewater treatment and disposal problems that may exist along the Outer Banks of North Carolina. In the Outer Banks as well as in other areas of the state, many lots exist which should not be developed with on-site wastewater treatment and disposal systems. This is due to the fact that neither engineering practice nor operational requirements are amenable to quick solutions. Somewhat of a hierarchy exists for recommending alternative on-site or modified conventional systems. Ideally, conventional systems with their limited O&M requirements and low initial installation costs would be the first system recommended. If soil and site criteria were such that a conventional system would not adequately function, then a low pressure pipe system would be recommended. Finally, if soil and site conditions are such that a low pressure pipe system would not function adequately, then a mound system would be recommended. In some cases, none of the on-site alternatives mentioned will function adequately. In those cases, the only apparent solution to the wastewater treatment needs is a community collection and treatment system. There are a number of options available for low cost community collection and treatment systems. These might include small diameter gravity sewers, vacuum sewers, or pressure sewers. Each of these options would then treat effluent on a site suitable for land treatment of the waste. This would eliminate discharge of effluent to sensitive environmental areas. A rigid set of site selection criteria and site evaluation criteria must be developed and utilized to insure that conventional systems and alternative on-site wastewater treatment systems function adequately and protect the sensitive environmental areas along the Outer Banks of North Carolina.

Site and Soil Conditions Suitable for Mound Systems

The mound system was adapted to conditions in North Carolina and tested throughtout the state in an effort to provide a means to overcome soils and/or site limitations which classified lots as unsuitable for either a conventional on-site system or a low pressure alternative system. These conditions include:

1. Somewhat poorly to poorly-drained soils which may exist along the Outer Banks
2. Excessively permeable sands which do exist on the Outer Banks
3. Soils with restrictive horizons, such as a high water table or an organic layer, which may occur at a shallow depth and which also exist along the Outer Banks.

Where these conditions exist, it is unlikely that conventional site modifications such as lot shaping, lot drainage, or community drainage can render a site suitable for absorbing and treating effluent.

The depth of mound fill material required in a mound varies with soil conditions underlying the mound and with depths to seasonal high water table or other restrictive horizons. Stewart (1977) and Stewart and Carlile (1978) indicate that the vertical lengths of unsaturated flow which yields optimum treatment may vary from 12 to 30 inches. This depth is directly related to the textural class of the soil underlying the mound. If, for example, a seasonal high water table exists at a depth of 12 inches from the soil surface and the soils are sandy, then 18 inches of mound fill material would be required to provide a 30-inch treatment zone between the absorption area in the top of the mound and the water table. In clayey soils which may occur along some of the western edges of the Outer Banks, flow paths of 12 to 18 inches are all that is required for mounds to function effectively. A mound system must be designed to match the absorptive and treatment capacities of both the site soil and the fill material utilized in construction of the mound. Often a great deal of disparity exists between the relative treatment capacities of fill material used in a mound and natural soil underlying the mound. In these cases, it is not uncommon to have basal area requirements four to five times greater than the treatment area requirements. Loading rates for mounds may vary from 0.1 gallon per sq. ft. per day to as much as 0.6 gallon per sq. ft. per day.

It is necessary to have a minimum of 12 inches of existing natural soil of suitable to provisionally suitable texture, structure and permeability above any restrictive horizons such as high water table or organic layer.

Appendix 3.3.3 Continued

An additional constraint on mounds may be the area requirements. Area requirements as mentioned before are dictated by soil conditions. Table 2 indicates some typical mound dimensions, per 75 gallons flow. In addition to these mound dimensions, septic tanks and pumping tanks must be located on the property at sufficient distances from wells or water lines, and the set backs from the property line boundaries and buildings must all be enforced. Additional information regarding distribution systems of mounds is found in the next section.

Table 2. Typical Mound Dimensions Per 75 Gallons Flow.

Loading Rate (gal/sq.ft./day)	Square Footage of Mound Area
.1	4500
.2	3750
.3	3000
.4	2250
.5	1500
.6	750

Low Pressure Pipe Systems

The LPP system was designed to overcome soils and site conditions which limit or render waste treatment impossible through a conventional soil absorption system. The primary objective of pressure distribution is to provide adequate purification of effluent before that effluent reaches either a perched water table or the true ground water table. Since unsaturated flow of septic tank effluent through a soil of approximately 12 inches (clay and clay loams) to 30 inches (sands) is sufficient to provide adequate treatment, appropriate soil depths are necessary. Obviously, many sites on the Outer Banks will require additional fill material which may be added above the natural soil surface to create the unsaturated flow zone of desired depth. Depth of soils from the soil surface to the seasonal high water table should be between 18 and 24 inches. Depths less than 18 inches to 24 inches will require the addition of fill material. In extremely sandy soils such as those which occur along the frontal dune, depths of as much as 36 inches may be required for pressure distribution systems to be used without additional fill material being required. This is necessary because the sands do not provide the same level of treatment as do the clays and silts.

The components of a pressure distribution system are a conventional septic tank or a two compartment septic tank, a pumping chamber, a submersible pump, a manifold and distribution system of small diameter PVC pipe, and suitable depth of permeable topsoil or topsoil plus fill material above a water table or restrictive soil layer.

System Design Considerations

The system design must be based upon both the daily wastewater volume to be treated and the natural soil material available on the site. A system must be sized such that it will accept the daily wastewater volume without surface seepage or continual saturated flow conditions underneath the system. The scheme for developing such a system includes:

1. The determination of the daily waste flow,
2. The determination of appropriate soil permeability data,
3. Determination of the dimensions of the system,
4. Design of the pressure distribution system, and
5. Design of the pumping system.

Each of these steps must be addressed by the designer in construction of a low pressure pipe system. Excellent purification of effluent from a low pressure pipe system can be obtained in North Carolina and on the Outer Banks if the system is designed appropriately. In order to accomplish this the system must be:

1. Sized to the required waste flow and loading rate,
2. Placed in the appropriate soil, and
3. Properly constructed, as planned.

As with any soils absorption system, some clogging of the absorptive surface will occur. This will occur even in sandy soils and may reduce the infiltration capacity of the system somewhat. In these highly permeable sands, this is a desired outcome. If the system is properly designed and loaded, such clogging, however, will not reduce the long-term effectiveness of the system. Recommended loading rates for various soils are:

1. Fine to coarse sands 1.2 gallons per square foot per day
2. Sandy loams 0.6 gallons per square foot per day
3. Clay loams 0.5 gallons per square foot per day
4. Clays 0.1 to 0.2 gallons per square foot per day.

These loading rates are contingent upon adequate depth of suitable soils above a water table. These rates should produce some unsaturated flow conditions provide adequate effluent purification and treatment, and minimize any clogging which may result within the fill material.

Distribution System

In order for this system to function successfully, the effluent must be distributed uniformly over the entire surface. This will enhance unsaturated flow conditions through the underlying soil material. The distribution system is the key factor in making a low presure pipe system work effectively. If effluent is concentrated in one area as is typical of a conventional gravity flow system, the effluent moves rapidly through the fill material under saturated conditions and may concentrate at one particular location underneath the system. This one area then becomes overloaded and results in either surface seepage or ground water contamination. Often the remaining part of the conventional system appears dry.

The primary method by which uniform distribution is obtained is through the use of a pressure system consisting of small diameter pipes connected to a manifold and dosed with a small one-quarter or one-half horsepower submersible effluent pump.

The pumping system is an important component in this process. The pump must be sized such that adequate dosing of the entire system will result before the effluent level in the pump chamber falls below the pump off level. Dosing too frequently will lead to poor treatment of effluent. Ideally, dosing frequencies of 2 to 4 doses per day are optimum. Under ideal circumstances, the volume of effluent discharged per dose should be four to eight times the total pipe volume. This will minimize differences in the volume discharge from orifices while filling the entire network.

Obviously there are a number of considerations which must be addressed during the siting and design of a low pressure pipe system or any other alternative. Because of this each system must be designed and tailored to a specific application. No two alternative systems are exactly the same. This is because of minute differences in soil characteristics or site characteristics. Adequate evaluation of alternative system design is necessary, and local health department officials are required to evaluate design before installation begins.

REFERENCES

Phillips et al. 1975. Soil Survey (Currituck, Dare, Hyde, Carteret, Onslow Pender, New Hanover and Brunswick Counties). USDA, SCS. In cooperation with N.C. Dept. of Natural Resources and Community Development.

Waste Source and Water Quality Studies, Surf City, N.C. U.S. Environmental Protection Agency, S&A Divison. In cooperation with N.C. Natural Resources, February-July, 1975.

Appendix Table 3.4.3.a. Bridges and Causeways which Provide Access to the Barrier Islands.

---

1. Wright Memorial Bridge
   Point Harbor to Kitty Hawk (Dare Co.)

2. Roanoke Sound Bridge & Causeway
   Roanoke Island to Bodie Island (Dare Co.)

3. Croatan Sound Bridge & Causeway
   Manns Harbor to Roanoke Island (Dare Co.)

4. Oregon Inlet (Bonner) Bridge
   Bodie Island to Pea Island (Dare Co.)

5. Atlantic Beach Causeway
   Morehead City to Atlantic Beach (Carteret Co.)

6. Cape Carteret Causeway
   Cape Carteret to Bogue Banks (Carteret Co.)

7. Onslow Beach Causeway
   Camp LeJeune to Onslow Beach (Onslow Co.)

8. State Road 210 Causeway (West Onslow Causeway)

9. Surf City Causeway
   Pender Co. to Topsail Island

10. Figure Eight Island Causeway
    (New Hanover Co.)

11. Wrightsville Beach Causeway
    (New Hanover Co.)

12. Carolina Beach Causeway
    (New Hanover Co.)

13. Caswell Beach Causeway (Oak Island)
    (Brunswick Co.)

14. Holden Beach Causeway
    (Brunswick Co.)

15. Ocean Islae Beach Causeway (north end)
    (Brunswick Co.)

16. Ocean Isle Beach Causeway (south end)
    (Brunswick Co.)

17. Sunset Beach Causeway
    (Brunswick Co.)

Source: North Carolina Transportation Map, 1980-81, Department of Transportation.

Appendix Table 3.4.3.b. Ferry Access to the Barrier Islands

State Operated

1. Currituck Sound Free-Ferry
   Mainland to Knotts Island
   (Currituck Co.)

2. Hatteras Inlet Free-Ferry
   Hatteras Island to Ocracoke Island
   (Dare and Hyde Counties)

3. Ocracoke-Swan Quarter Toll-Ferry
   Ocracoke Island to Swan Quarter
   (Hyde Co.)

4. Cedar Island-Ocracoke Toll-Ferry
   Ocracoke Island to Cedar Island
   (Carteret Co.)

5. Southport-Fort Fisher Toll-Ferry
   Carolina Beach Island to Southport
   (Brunswick Co.)

Private Ferries

6. Three private ferries operate between the mainland in Carteret Co. and the Core Banks (Cape Lookout National Seashore) under National Park Service permits.

Source: North Carolina Transportation Map, 1980-81, Department of Transportation.

Appendix 3.5.3.a Waterfowl Hunting Around the Barrier Islands

The majority of waterfowl harvested in North Carolina are ducks. During the 1978-79 season an estimated 200,000 ducks, 6,000 Snow Geese and 5,000 Canadian Geese were harvested by hunters. The key species of waterfowl hunted in North Carolina varies geographically:

Barrier Islands of Currituck Sound. Widgeon is the primary waterfowl harvested in addition to black duck, mallards, gadwall, ruddy ducks, Canadian geese, and snow geese. This is also the prime area in the state for wintering ring-necked ducks, whose population appears to be declining.

Western Pamlico Sound. (Found in the diked-off Juncas marshes.) Puddle ducks including pintail, widgeon, and black ducks; in open areas the primary ducks harvested are diving ducks, which include the canvasback, redhead and scaup.

Eastern one third of Pamlico Sound. This area is a shallow shoal, one to two feet deep in many places, providing excellent waterfowl habitat. The key species harvested are redheads, Canadian geese and brants as well as puddle ducks (such as scaup and pintails).

Core Sound. The key species harvested in this area are diving ducks including redhead, canvasback, scaups and brants.

A key concern of local waterfowl biologists is the gradual diminishment of waterfowl habitat in coastal North Carolina. As waterfowl wintering grounds are lost, the number of birds that can winter over and the length of time they can stay (food being the controlling factor), is greatly reduced. Waterfowl displaced to lower quality habitat have a decreased chance of survival. In many cases they become concentrated in the remaining habitat resulting in its further degradation. Florschutz (1981) feels very strongly that small watershed drainage projects by the Soil Conservation Service and Corps of Engineers under the guise of flood control have resulted in drainage of bottom land hardwoods and swamps affecting redistribution and the total number of wintering waterfowl in North Carolina. For the most part, he feels this has provided access to these low lying areas for farming. Recent CAMA regulations have placed controls on such activities, but still he feels it is a creeping process which is slowly destroying prime waterfowl habitat. In order to assure that adequate habitat is maintained to support a viable wintering waterfowl population, the regional waterfowl biologists have recommended the following areas be obtained by the state or federal governments.

- Williamston northward on the Roanoke River
- Currituck Banks
- Dew and Narrow Islands
- Tulls Bay
- North River
- Several private diked impoundments adjacent to Pamlico Sound

In recent years a major controversy has originated over the intended use and therefore management of Currituck Sound. Currituck Sound is currently a freshwater habitat which acts not only as a wintering ground for approximately one-third of the total North Carolina duck population but also provides some of the best large-mouth bass fishing in the U.S. On the other hand, there is a strong movement by commercial fishermen who would like to see this water body become more brackish in order to provide additional habitat for commercially important fish species.

To explain this controversy, an historical perspective is provided. The native grasses in Currituck Sound historically were:

- Redhead grass, Potomogeton profoliatus, requiring 5-10% sea water (Salinities of 1.8 - 3.5%.)
- Sago pondweed, Potomageton sectinatus, requiring 5-20% sea water (Salinities of 1.75 - 7%.)
- Widgeon grass, Ruppia maritima, requiring 15-60% sea water (Salinities of 5.3 - 21.0%.)
- Shoal grass, Halodule beaudettei, and eel grass, Zostera marina, both species requiring 50-60% sea water (Salinities of 18-21%.)

In the late 1940's these native species began disappearing and, along with them, the wintering waterfowl species who utilized these plants as a source of food. As these plants disappeared, the bottom of Currituck Sound became less stable, turbidity increased and reduced light penetration necessary for photosynthesis is believed to have accelerated their decline (Florschutz 1981).

As a result of this two-fold decline in both aquatic plants and waterfowl, an intensive six year (1957-64) study was undertaken in Maryland, Virginia and North Carolina by John Sincock of the U. S. Department of Interior. As this study was completed, the exotic aquatic plant Eurasion milfoil, Myriophyllum sp., which had already infested the Chesapeake Bay in the late 1950's and early 1960's, choked the water of Currituck Sound. With the invasion by this plant, the water fowl populations returned.

The reason for the decrease in the native aquatic plants was never clearly determined; however, many feel it has to do with the federally sponsored dune stabilization programs begun in the 1930's that reduced overwashing and inlet formation along the barrier islands. This in turn is thought to have resulted in a gradual decrease in salinity thought to be the key limiting factor in the survival of these aquatic plants.

On the other hand, Eurasion milfoil is better able to survive the reduced salinities and increased turbidities that followed. The increase in milfoil stabilized the Sound bottom, increased fish production and decreased turbidity. The decrease in turbidity allowed some of the native grasses to start coming back in the early and mid-1970's (Florshutz 1981).

Beginning around 1978, milfoil production began decreasing, not only in Currituck Sound but in the shallow tributaries of Albemarle Sound (Connally 1981). At the same time commercial fishing had fallen off significantly.

Although not backed by research data, this could imply nutrient pollution. Such pollution could possibly result in algal blooms sufficient to shade out the milfoil and which have been proven to cause fish kills due to high diurnal oxygen fluctuations. Along with this nutrient pollution has been the already mentioned increase in red sore disease that has infected fish.

Commercial fishermen are pushing strongly to have a cut made through the Currituck spit, and/or if the next major storm causes an opening, they desire it to be maintained. Their feeling is that this will flush Currituck Sound of any pollutants and raise the salinities necessary for increased commercial fish production.

On the other hand, the sportsfishermen see this action as infringing on their recreation opportunities by wiping out important freshwater fish species, particularly the largemouth bass. Supporting the sportsfishermen are most waterfowl experts who fear any changes to Currituck Sound will affect the major winter grounds for waterfowl in North Carolina.

Black Duck Habitat. Black ducks are local breeders and land nesters. Their populations have been severely affected by coastal development south of Maryland where freshwater and brackish water ponds have been drained for the building of homes. Development on the Outer Banks has displaced a large number of these birds. At one time, from Cape Lookout south along the barrier islands, black duck habitat existed. This habitat, however, has been destroyed (Donnally and McClanahan 1981).

In the early 1960's, Otto Florshutz, presently Regional East Coast Biologist with the U. S. Fish and Wildlife Service, brought with him a technique of mosquito control from the Mid-Atlantic states. Typically, the salt marsh mosquito requires 2-3 weeks of dry marsh followed by flooding to complete its life cycle. In the past, ditching was a common practice that resulted in the drainage of marshes and their loss as a useful waterfowl habitat. The new technique helped to control local mosquito populations in addition to providing excellent waterfowl habitat. High marshes of *Juncus romerianus* (black needlerush) were diked,burned and flooded. *Ruppia maritima* (widgeon grass) became the dominant aquatic plant. This provided excellent puddle duck habitat primarily for black duck, pintails and widgeon. A number of these important diking operations are on private lands and currently are in a degenerated state. Local waterfowl experts feel that this habitat should be in state or federal hands in order to assure a viable black duck and puddle duck population in North Carolina.

Key areas of black duck habitat which local waterfowl experts feel should be placed into public lands include:

All of Currituck Sound
Kill Devil Hill area
Southern half of Roanoke Island
Chowan River, Cholerain to the Virginia border (bottom and hardwood being converted over short-rotation pine for pulp production)
Long Shoal Point
Two sites around Hobucken (diked juncus marshes)

Appendix 3.5.3.a Continued

Two sites around Mow Point - Whartonsville Area (diked juncus marshes)
Roanoke River Bottomlands (bottomland hardwood being preferred over short-rotation pine.)

Another major problem appears to be the raising and releasing of mallards from Currituck, north. This is affecting the black duck population by having females released into the area during the black duck breeding period. Apparently the female black ducks prefer breeding with male mallards over breeding with male black ducks. This is resulting in hybridization and local degeneration of the black duck population (McClanahan 1981).

Canadian Geese Populations. Data provided by Florshutz (1981) indicate that the population of Canadian geese in North Carolina decreased from approximately 151,000 in 1953 to about 29,000 in 1980 while the total Atlantic Flyway population increased from about 490,000 to 780,000 in the same period. Decreases in Canadian geese populations in North Carolina are primarily the result of changes in farming and wildlife management practices. Two different Canadian geese populations use the Atlantic Flyway, the James Bay population which are corn feeders and the Eastern Canadian Maritime population which are aquatic plant feeders. Beginning in the 1960's, farmers on Maryland's Eastern Shore began converting to corn which was allowed to dry on the stalk prior to being harvested. This made it readily available when the geese began arriving in the fall. Also additional refuges were developed to feed and protect Canadian geese. These two activities induced the James Bay population to remain in Chesapeake Bay. Additionally, farm management practices in North Carolina changed, reducing the availability of corn in North Carolina. Varieties of corn were developed which ripened by August and were placed in mechanical dryers. This development took place in order to assure harvesting prior to the September storm period that had wiped out crops in the past. It also became popular to plow under the stubble. By October when geese began arriving, new corn was beginning to sprout but was usually killed by frosts and never provided food for the geese.

A decrease in milfoil production about 1978 resulted in decreased numbers of the eastern maritime population of Canadian geese migrating into North Carolina. Additionally, in North Carolina, local hunting laws were changed extending the hunting day from 4:00 p.m. to 6:00 p.m. resulting in substantially increased goose kills, as they could be more easily harvested on their evening flight in search of food.

Snow Goose Habitat. A number of important habitats exist on barrier islands that are critical to overwintering of snow geese. Snow geese rely heavily on rhyzomes, tubers and root stocks of various marsh plants on the islands. Traditionally they have also used the barrier island dunes for preening and resting areas and to obtain grit. Development of the barrier islands has reduced this habitat. Marshes have been drained and filled in and homes have been placed on the primary dunes. Local waterfowl experts expressed very strong opinions on the need to control spreading barrier island development in the northern part of the state in order to assure adequate habitat for these birds (Florshutz, Donnelly and McClanahan 1981).

Appendix 3.5.3.a Continued

Waterfowl experts agree that, at present, pollution is not the controlling factor affecting duck populations. The key to long-term trends in waterfowl populations lies in the loss of habitat and the various changes in waterfowl management practices. Additionally, on a year to year basis, exceptionally cold winters push large numbers of waterfowl into the North Carolina area that would normally have terminated their flights in the Chesapeake Bay area (Donnelly, McClanahan and Florshutz 1981).

Appendix 3.5.3.b Geographical Distribution of Sportfishing along the Barrier Islands of North Carolina

The following information was extracted from a detailed conversation with Dr. Peter Fricke, sport fishery expert formerly with East Carolina University and presently with the National Marine Fisheries Service. The information provided by him comes out of sport fishing surveys conducted through the University of North Carolina, Sea Grant College Program funding by Dr. Leon Abbas (N.C. State), Dr. James Sabella (UNCW), Dr. Richard Dixon (UNCW) and Marcus Heburn, (Sea Grant). Additional sportfish data was provided by C. S. Manooch, a sportfishery expert with the National Marine Fishery Service in Beaufort, N.C.

Ocracoke to the Virginia line. Currituck Sound is considered one of the best largemouth bass fishing sites in the United States. Other important sportfish taken from these waters include black crappie, chain pickeral, bream, white perch, and pumpkinseed (US Fish and Wildlife Service 1980).

Estuarine and ocean fishing from Ocracoke to the Virginia line is predominated by surf and pier fishing from the ocean beaches of the barrier islands and offshore boat fishing. Over the last three years the following numbers of surf fishermen have been reported by the National Park Service on the Cape Hatteras National Seashore alone:

	Total Number of Visitors	Surf Fishermen	Percent
1980	1,810,658	210,268	11.6
1979	2,143,393	240,992	11.2
1978	2,434,849	475,642	19.5

Ocracoke to New River Inlet. From Shackleford Banks to Long Core, access to surf fishing is controlled in many cases by marinas that require rental of cabins. Surf fishing on Core Banks is controlled by the National Park Service. In 1980, approximately 3,800 man days were spent surf fishing on Core Banks. Presently a major dispute exists between environmentalists, who desire to see the Core Banks set aside as a primitive area, and surf fishermen, who are demanding limited access to the ocean beaches for their off-road vehicles (ORV's) in order to follow the migrating fish up and down the beaches (Willis and Rittle 1981).

Most boat fishing in this area is off-shore. Since Ocracoke and Drum Inlet are extremely hazardous, most boat fishing occurs southward from Cape Lookout. Small boats also commonly fish the inland waters, especially the sounds during the fall of the year.

New River Inlet to Cape Fear. The New River Inlet to Cape Fear sport fishery is a very complex sound/inlet/off-shore fishery under pressure due to its location near major population centers.

Cape Fear to the South Carolina Line. From Cape Fear to the South Carolina Line most sportfishing occurs behind the barrier islands and in the inlets. During exceptionally good weather, off-shore fishing on natural reefs for snappers and grouper is extremely popular.

Appendix 3.5.3.c Economically Important Sportfishing along the Barrier Island of North Carolina

Off-Shore Tournament Fishing

A large portion of the off-shore tournament and charter boat fishery of North Carolina takes place on large, charter boats from marinas on the barrier islands. Key sport fishing areas on the barrier islands are Oregon Inlet, Hatteras, Ocracoke, the Beaufort/Medford/Atlantic Beach Complex, the Swansboro area, Wrightsville Beach area and, to a lesser degree, Southport and Calabash.

The major value of tournaments is that they bring in money to the barrier island communities before and after the main summer tourist season. The University of North Carolina Sea Grant College Program is presently funding research to study the economic value of these tournament fisheries. The two major off-shore fishing tournaments are for bill fishing and king mackerel.

The bill fishery, running from mid-May through September, is primarily for white and blue marlin, swordfish, sailfish, tuna, mackerel and dolphins. The most productive of the bill fishing tournaments are the Hatteras and Oregon Inlet bill fishing tournaments that occur in late summer and early fall. The major fish taken is the white marlin.

The average bill fisherman has a mean income of $80,000 per year and operates a 9.2-18.3 m (30-60 ft) boat costing a minimum of $30,000 (Coastal Watch, October 1980). A tournament of 100 entries could provide about $430,000 to a barrier island community (Abbas 1981).

The off-shore king mackerel fishery is a seasonal tournament fished within ten miles of the coast. It is fished with smaller boats averaging from 4.9-9.2 m (16-30 ft) in length and costing $4,000 to $60,000. The median income of a mackeral fisherman is less than $30,000 (Coast Watch, October 1980). At other times people who are involved in this fishery will fish inlets for sea trout. One of the largest tournaments held in the fall of each year is the US Open King Mackeral Tournament promoted by the Southport-Oak Island Chamber of Commerce, which brought in $200,000 worth of business this past year. A tournament of 100 entries typically provides an economic return to the community of about $81,600 (Abbas 1981).

Charter Boat Fishing

Approximately 85 of 135 charter boats in North Carolina operate out of the barrier islands. In 1978 the 135 boat fleet grossed $2,409,330, averaging $17,847 per boat (Manooch et al. 1978). These figures do not account for money spent on hotels, food, gas and gear. A small portion of these revenues come from inshore charter boat fishing. A portion of the off-shore tournament fisheries which charter local boats is also accounted for in these statistics. The major charter boat fisheries include offshore trolling, inshore trolling, bottom fishing for reef fish and scuba diving.

Surf Fishing Tournaments

Surf fishing tournaments in North Carolina occur on the ocean side of the barrier islands. These tournaments occur in the spring and fall, providing additional income to the barrier island communities apart from the main summer tourist season. Fishing takes place for the estuarine-dependent bluefish, channel bass, drum, croaker, flounder and sea trout.

Two of the oldest sportfishing tournaments are the Nags Head Surf Fishing Tournament and the Cape Hatteras Anglers Club Surf Fishing Tournament. The Nags Head tournament was reputed to have brought in $50,000 in business to the Hatteras community this past year (Coast Watch, October 1980). A tournament of 100 entries can provide an economic return of as much as $100,000 to a community (Abbas 1981).

Private Estuarine Sport Fishing.

Most of the 1.5-2.0 million angler days spent sport fishing from boats in North Carolina's intracoastal waters are in small privately owned boats. Pier fishing is also an important recreational activity; however, there are no estimates at present of its relative importance compared to the other sport fisheries. The key species taken by these two fisheries are croaker, gray trout, flounder and bluefish.

Shark Fishery. A small sport fishery for sharks also exists with an estimated 60 boats (of which 5 or 6 are charter boats). Fifty percent of these boats are estimated to fish out of the barrier islands from Hatteras to Ocracoke, with the remainder fishing out of the Carteret County Area (Fricke 1981). The total value of these fisheries to the barrier islands proper is presently very difficult to estimate. As findings from the recent sportfishing studies sponsored by Sea Grant are published, these figures should become readily available.

Appendix 3.5.3.d Major Intracoastal Commercial Fisheries of North Carolina

The information contained in this appendix is provided by the following personnel: Steve Ross, Katy West, Dennis Spitsbergen, Rich Carpenter, Mike Marshall, Fintress Munden, Terry Sholar and Clifton Harwell of the North Carolina Division of Marine Fisheries; Gordon Thayer, National Marine Fisheries Service; and several commercial fishermen.

Between 1970 and 1979, statistics compiled by the N.C. Division of Marine Fisheries showed a major increase occurred in the ex-vessel value of the commercial fisheries in North Carolina. In 1970, the ex-vessel value for inland waters was about $5.0 million versus about $25.0 million in 1979, a five-fold increase. Commercial fishermen and state fisheries experts feel this increase in value is in part due to inflation, to increased fishing effort and to improved fishing gear. Many people interviewed during this study believe that these landing statistics may mask a real problem: pollution (especially from the mainland) and an overall decline in fishery stocks.

Oyster Fishing. Commercial oyster fishing in North Carolina is restricted to the intracoastal waters from Roanoke Island south. The season generally runs from October through April of each year. North of Roanoke Island and Currituck and Albemarle Sounds, salinities are presently too low to support a viable industry (Tillette 1981).

The oyster fishery can be further subdivided into a subtidal fishery north of Morehead City and an intertidal fishery south of Morehead City. Interviews with commercial fishermen (Foster and Fulcher 1981) indicate that little or no commercial oystering takes place along the barrier islands from Oregon Inlet to Ocracoke. Most of the commercial oystering in Pamlico Sound takes place on the mainland side of the sound. A preliminary investigation by Sholar (1980) indicates that major salinity changes resulting from inland development on the Coastal Plain and in the Piedmont region of North Carolina have greatly reduced the production of oysters in western Pamlico Sound. Indications are that over the last 30 years, commercially harvestable beds have been displaced ten miles downstream in the Neuse and Pamlico Rivers. Pungo River oyster production has degenerated due to decreased salinities caused by the Pungo River being connected to the Alligator River by the Intracoastal Waterway. Decreased production in Rose Bay and Swan Quarter Bay appears also to have resulted from reduced salinities caused by drainage from large corporate farms that exist on the Albemarle Peninsula (Jones 1981).

Subtidal oyster fishing appears to take place on both the mainland and on the barrier island side of Core Sound. Some individuals have shown concern that the natural closure of Drum Inlet that is presently taking place could result in decreased salinities and reduced oyster production in the Sound. In the past, this inlet has been kept open artificially by the Corps of Engineers. Now that the inlet is under the jurisdiction of the National Park Service, many believe that natural processes will be allowed to take place, resulting in its closure.

South of Morehead City the estuarine area becomes narrow. Fishing pressure for intertidal oysters is extremely heavy, and commercial harvesting takes place in and around the barrier islands.

Appendix 3.5.3.d Continued

The N.C. Division of Marine Fisheries practices various management techniques to promote oyster production in North Carolina:

- Small bunched or "cluster" oysters are harvested and replanted so that large singles may develop.

- Oyster stocks from polluted waters are typically harvested by the State and moved to depuration areas (areas of clean water where the oyster is given a chance through filtration to rid itself of possible bacteria and viral contaminants). After a given period of time, these oysters may be legally harvested.

- Commercial oystermen may obtain special permits to harvest oyster stocks from polluted waters, transporting them to their leases where they are held for a specified time to assure depuration.

- Because major acreages of commercial and sport oyster beds have been closed due to pollution, the Division of Marine Fisheries has also enacted a shell planting program. Since the area of potential shellfish habitat in the state is so large, the State's goal is to locate geographically these plantings so that they are available to a large segment of the public up and down the coast of North Carolina. In Pamlico Sound, the State allows the commercial fisherman to self-regulate these plantings (Marshall 1981).

The dockside value of the oyster fishery in 1979 was $925,000 based on information from fish dealers. A state shellfish tax requiring oystermen to pay eight cents on the bushel has led to under-reporting. However, the Division of Marine Fisheries is presently attempting to have this tax eliminated in order to better enable management of this fishery (Marshall 1981). Typically, the total value to the economy, accounting for mark-ups and profits to the middlemen and sale to consumers, is 2.5-3.0 times the dockside price for most commercial fisheries (West 1981). This total value to the economy then was approximately $2.3 to 2.8 million in 1979.

Bay Scallop Fishery. The primary geographical areas of the bay scallop fishery are Core and Bogue Sounds and to a lesser degree Back Sound and the New River. Bay scallops are limited to these areas (Marshall 1981). Some characteristics of bay scallops include:

- They prefer salinities of 20 parts per thousand or greater. Salinities of Pamlico Sound and north are generally too low to permit commercially harvestable quantities of scallop populations.

- The bay scallop's life cycle is closely tied to the availability of marine grass beds. Generally, these grass beds are not prolific south of New River.

Harvesting of bay scallops is strictly controlled by the Division of Marine Fisheries, typically occurring during very short seasons (Decemoperation. In 1979 this small geographical fishery of short duration provided approximately $514,000 dockside to the commercial fisherman. The total value to the economy can be estimated at $1.3 to $1.5 million.

Because bay scalloping takes place primarily by dredging in and around marine grass beds, concern has been shown for the destructiveness of such activities on the important nursery ground. Thayer (1981) recommends, as a form of management, that stricter control be placed on the areas of marine grasses where harvesting of scallops is practiced. He recommends that a rotational system be established so that grass beds from which scallops have been harvested in one year are closed for a set period of time (yet to be determined) and then reopened once the Division of Marine Fisheries is sure of the grass bed's full recovery. Division of Marine Fisheries personnel, however, do not think this is practical.

Clam Fishery. The major species in the North Carolina clam fishery is *Mercenaria mercenaria*, hard shell clam. This species prefers salinities of 15 parts per thousand or greater. The commercial fishery for this species in North Carolina takes place from Core Sound to the South Carolina line.

In Core Sound the major means of harvesting clam is by clam kicking. This method uses prop wash directed from the boat to expose the clams from the bottom after which they are collected by a dredge. This form of harvesting clams is considered to be very destructive to the bottom and to marine grasses. As a result, the North Carolina Division of Marine Fisheries has designated areas opened and closed to this means of harvesting in Core Sound.

South of Core Sound, use of a clam rake is the major means of harvesting clams. One form of raking imported into the area by Long Island clam fishermen is the bull rake. This is a very wide rake with a yoke-like handle that is worked in a plow-like fashion, thus the origin of its name. The bull rake is considered to be very destructive to marine grass beds (Thayer 1981). As a result, the N.C. Division of Marine Fisheries has had to place restrictions on the size of the bull rake. Details on these restrictions are found in the North Carolina Fisheries Regulations for Coastal Waters, 1981.

Hard clams are marketed by size, the smaller top necks (shell length less than 50 mm) and little necks (shell length 50-67 mm) having the best market value. Cherry stone clams (shell length 66-79 mm) and the largest chowder clams (shell length greater than 80 mm) have the lowest monetary value.

At present, the clam fishery is economically more important than the oyster fishery. Fishermen are receiving as much as 15 cents per little neck clam which is eventually sold in New York. Some experts fear fishermen are encouraged to harvest clams illegally from polluted areas due to their high price (Spitsbergen 1981). In 1979 this fishery at the dock was valued at $4,475,000 (an estimated $11-13 million in 1979 to the total economy).

Blue Crab Fishery. The blue crab, *Callinectes sapidas*, fishery occurs throughout the entire intercoastal waters of North Carolina. However, the principal fishery is in Pamlico Sound and is important along the Outer Banks.

Fishing is primarily through the use of crab pots (traps) or by trawling. In 1979 the blue crab hardshell fishery brought in $4,621,000 at the docks ($12-14 million to the total economy). A less important soft shell fishery also exists in North Carolina.

Shrimp Fishery. In 1980 it was estimated that the shrimp fishery of North Carolina yielded $9,729,000 dollars dockside to the fishermen. Much of this fishery takes place in the intracoastal waters. Three key species of shrimp are taken: brown shrimp, pink shrimp and white shrimp.

The major production and the major nursery of brown shrimp occurs in Pamlico Sound. Of the three species, this shrimp is the most economically important. This species spawns off-shore and enters the estuarine nursery grounds in April, goes up the tidal creeks and marshes of western Pamlico Sound and is commercially fished from June-April. This species is sensitive to salinities, requiring a salinity of about 10 parts per thousand in the nursery areas. In recent years brown shrimp populations have become quite variable due to the channelization of rivers, clear cutting of forest for farming on the Coastal Plain, and the growing urbanization in the Piedmont areas of the state, all of which promote runoff and sudden fluctuations in salinity in the brown shrimp's nursery grounds. Some experts feel it may not be as much decrease in salinity as the physical barrier of fresh water flow during the spring of a wet year that prevents the larval shrimp from getting to their nursery grounds (Spitsbergen 1981). Production of brown shrimp in Albemarle and Currituck Sounds is non-existent since these areas are freshwater. South of Core Sound the production of brown shrimp is limited the small size of the estuaries and due to limited nursery grounds.

The geographical range of the pink shrimp fishery in North Carolina is primarily confined to the barrier island side of the sounds from Cedar Island to Ocracoke for two major reasons:

- The pink shrimp prefers salinities of 20 parts per thousand or greater.
- The pink shrimp's life cycle is closely tied to the availability of marine grass beds.

The biggest producer of pink shrimp is Core Sound, and to lesser degrees, Back and Bogue Sounds and the seaside marshes of Brunswick County (Spitsbergen 1981). The pink shrimp fishery consists of a fall and spring fishery. Spawning occurs off-shore or in inlets, and the larval shrimp enter the sounds as larvae from mid-summer to early fall. Commercial fishing for these first year class fish occurs as they move back out to sea in the fall. Some of these young-of-the-year over-winter in the sounds, burying themselves in the bottom; they are fished a second time in the spring when water temperatures reach 11.2°C (50°F) and they come out of the mud (Harwell 1981). Severely cold winters can also result in a die-off of over-wintering pink shrimp.

The white shrimp fishery is limited to the southern half of North Carolina and is considered to be in a degenerated state for a number of reasons, all of which are hypotheses:

Appendix 3.5.3.d Continued

- North Carolina is the northern range for this species; therefore, environmental conditions would naturally be marginal (Harwell 1981).

- Other Division of Marine Fishery personnel, in reviewing this appendix, expressed their opinions that cold winters in recent years have been the primary reason for the lack of white shrimp. This species is more temperature sensitive than either the brown or pink shrimp. Sudden drops in temperature below 8.1°C (45°F) can result in massive kills of white shrimp or can force them to move off-shore into deeper water. Typically, the white shrimp spawn off-shore and move up tidal creeks in late summer and early fall and are fished until cold weather forces them into deeper waters.

- Division of Marine Fishery personnel feel that the often referred to Hurrican Hazel is probably not the direct reason for the long term decline in North Carolina's white shrimp populations. Some, as of yet undetermined, environmental condition(s) changed which resulted in this decline. Many commercial shrimp fishermen relate this decline to the period following this hurricane.

- Because of a number of environmental factors, including decreased flow during estuarine migration and its adaptability to lower saline conditions, the white shrimp moves further up-river than the other two species. Robert Jones (1981), a commercial fisherman and dealer from Broad Creek, believes the white shrimp is therefore more susceptible to pesticide and herbicide pollution entering the waterways as a result of changes in farming practices such as ditching to drain marginal land. However, Division of Marine Fishery personnel do not believe that toxins such as pesticides are the cause for the decline in white shrimp populations since the brown and pink shrimp populations would have also been impacted.

The 1979 dockside value of shrimp harvested in intercoastal waters was $6,439,000 ($16-19 million to the total economy).

Fin Fisheries. The commercial intercoastal fin fisheries in North Carolina are very difficult to manage. The major species in the fishery (southern flounder, croaker, spot and gray trout) move up and down the Atlantic Coast. A species caught in North Carolina may have been spawned and had its nursery grounds in the Chesapeake Bay and visa versa. Managing such a fishery and assuring the availability of viable finfish stocks becomes a complex issue. A key point is that pollution and destruction of nursery grounds in another state have the potential to affect the commercial fin fishery of North Carolina. The reverse could also be true.

The Southern Flounder Fishery consists of an inshore pound net fishery and a trawl fishery. The inshore pound net fishery is primarily in Pamlico Sound around Ocracoke south through Core Sound and Back Sound, taking place during the fall months (Ross 1981). The pound net is a very simple device. A leader, running perpendicular from shore, turns migrating fish and guides them into a staked net which forms an impoundment. Once inside the pound, the concentration of fish are harvested.

Appendix 3.5.3.d Continued

Although officially illegal to trawl for any finfish in the sounds, a trawl fishery exists, claiming that southern flounder catches are incidental to trawling for crabs. The trawl fishery takes place primarily in Pamlico Sound and its tributaries. The flounder fishery in the intercoastal waters of North Carolina brought in $1,037,000 ex-vessel ($2.5-3.5 million to the total economy in 1979.

Sciaenid Fishery. Croaker, spot and gray trout, or weak fish, are fished by pound net and by long haul seines. The long haul seine is a 1000-1450 m net, 3 m deep, and is pulled by two 9.2-13.7 m. boats up to a distance of 2-3 km. This technique originated in North Carolina around the early 1900's and is unique to the area. The long haul fishery is economically the most important intercoastal fin fishery in North Carolina. In 1979 these species of fish harvested in intercoastal waters of North Carolina had a total ex-vessel value of $4,018,000 ($10-12 million to the total economy).

The long haul fishery for croaker, spot and gray trout takes place in Pamlico Sound and its tributaries, Core Sound, and to a lesser degree, Back and Bogue Sound. The long haul croaker fishery takes place mostly in the spring, landing locations varying seasonally with fish movement. The long haul spot fishery occurs during the late summer and fall months, while the gray trout are landed during the spring, summer and fall (Ross 1981). The pound net fishery for croaker, spot and gray trout takes place from Ocracoke northward in Pamlico Sound. These species are landed during the spring, summer and fall (Ross 1981).

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